The role of the city-scale in energy transitions: heat networks in England and Germany

Submitted by Jessica Sophie Britton, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Environment, Energy and Resilience, September 2018.

(Signature)…………………………………………………………………………

Abstract

This research explores the role of cities in energy transitions using heat networks as a case study. Drawing on both discursive institutional and socio-technical transitions literature the interaction of discourses, ideas and institutions are analysed in relation to heat networks in England and Germany. Heat networks are framed within this research as embedded within wider debates regarding scales of governance, scale of energy provision and the role of various forms of state, with the co-production of discourses and institutions reflecting the struggle between these competing ideas.

The thesis highlights the complex interactions between national and local scales in mediating material change to energy systems. At the local scale, in both countries, there was a growing narrative of the need for local governments to adopt more direct forms of governance in order to secure wider public good benefits of energy infrastructure. In developing heat networks all locations were adopting multiple roles but there was increased focus on ensuring modes of governing. These findings provide an empirical demonstration of the multiple modes of governing adopted by local governments, and suggests that previous assertions that England and Germany are converging on an ‘enabling’ model of climate change governance may no longer be the case.

Much discursive institutional literature presents ideas as influencing policy outcomes only when fully formed (Carstensen and Schmidt, 2016; Gillard, 2016), however this research suggests that the contestation of deeply held views can be constituted through not a single large-scale crisis but the amalgamation of several emerging challenges to existing ideas. A loss of confidence in the private sector to deliver the best outcomes, a financially constrained public sector, growing familiarity with sustainable energy projects in many local authorities and increasing recognition of the potential for heat networks to support whole system approaches to decarbonisation all led to ideas about the role of local government in the energy system to be challenged. This provides insight into how ideas can be influential, potentially at different scales, without necessarily being dominant nationally, or used consistently across local actor networks. At the same time obdurate existing storylines, such as the need to de-risk commercial finance, can act to marginalise other storylines. This highlights the complex interaction between dominant and emerging storylines with ideational bricolage at the local level leading to a reappraisal of the role of local government in energy system change. This was, to a degree, providing a route to resist embedded national norms and providing a platform for a stronger local governance role to be debated in relation to decarbonisation and energy system change.

Applying a discursive institutional approach is also demonstrated to add richness to explorations of regime politics within socio-technical change, particularly in relation to investigating processes of change at different scales. Socio-technical regimes are often characterised as stable with relatively short periods of change initiated by niche experimentation. Incorporating a discursive approach provides for a more diffuse and gradual explanation for change, enabling exploration of how individual experiments link to long-term debates at both the local and national scale.

Acknowledgements

When I first completed my undergraduate degree – more years ago than I like to remember – I remember being amazed that anyone would want to continue studying for a Masters or Doctorate when there was a ‘real world’ out there to get stuck into. How things change. After spending a few years working in sustainability and energy policy, I grew increasingly frustrated that, although there were lots of amazing projects happening, more rapid and widespread change was slow. Being able to re-enter academia and work on some of the big questions as to why changing our energy system is so difficult has been a privilege. I’ve had the freedom to pursue the areas I’m interested in and a post-graduate lifestyle in Cornwall has been pretty good too.

Completing this thesis has been a rather longer journey than I originally expected, with both my CV and family expanding during the process. Although it may have felt never-ending at times it would have been absolutely impossible for me to have finished without the support and guidance of a large number of people.

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Abbreviations

ADE	Association of Decentralised Energy
AGFW	Der Energieeffizienzverband für Wärme, Kälte und KWK (German Energy Efficiency Association for District Heating, Cooling and CHP)
APSE	Association of Public Service Excellence
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle (German Federal Office of Economics and Export Control)
BDEW	*Bundesverband der Energie und Wasserwirtschaft (German* Association of Energy and Water Industries)
BEIS	Department of Business, Energy and Industrial Strategy
BERR	Department for Business, Enterprise and Regulatory Reform
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry of Economic Affairs and Energy)
CCC	Committee on Climate Change
CCS	Carbon Capture and Storage
CEP	Community Energy Programme
CHP	Combined Heat and Power
CIBSE	Chartered Institution of Building Services Engineers
CMA	Competition and Markets Authority
CSEP	Community Sustainable Energy Programme
DBFOM	Design, Building, Finance, Operate and Manage
DCLG	Department of Communities and Local Government
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Food and Rural Affairs
DENA	Deutsche Energie-Agentur (German Energy Agency)
ECO	Energy Company Obligation
EEG	Erneuerbare-Energien-Gesetz (German Renewable Energy Sources Act)
EfW	Energy from Waste
ELENA	European Local ENergy Assistance
EUETS	European Union Emissions Trading Scheme
GQCHP	Good Quality Combined Heat and Power
GW	Gigawatt
GWth	Gigawatt thermal
HNDU	Heat Networks Delivery Unit
HNIP	Heat Network Investment Project
ICLEI	Local Governments for Sustainability
IPPR	Institute of Public Policy Research
JV	Joint Venture
KWK-G	Kraft-Wärme-Kopplungsgesetz (German Combined Heat and Power Act)
LCIF	Low Caron Infrastructure Fund

MAP	Market Incentive Programme (Germany)
MLP	Multi-Level Perspective
MW	Megawatt
MWth	Megawatt thermal
NGOs	Non-Governmental Organisations
OECD	Organisation for Economic Cooperation and Development
PV	Photovoltaics
PWLB	Public Works Loan Board
RHI	Renewable Heat Incentive
SNM	Strategic Niche Management
STS	Science and Technology Studies
TINA	Technology Innovation Needs Assessment
TIS	Technological Innovation Systems
TMN	Transnational Municipal Networks
UBA	Umweltbundesamt (German Federal Environmental Agency)
UK	United Kingdom
UKDEA	UK District Energy Association
UNEP	United Nations Environment Programme
VKU	Verband kommunaler Unternehmen (German Association of Local Utilities)

Chapter 1: Introduction

1.1 Overview and context: heat and cities

It is now widely accepted that addressing climate change will necessitate fundamental restructuring of our energy systems. While many of the technologies to reduce emissions are well established, progress against energy decarbonisation targets is slow and researchers are increasingly seeking to explore the political and governance processes that are central in shaping the development of energy systems (International Energy Agency, 2018). Despite this, sub-national governance interactions remain neglected as a research focus and there are particularly limited contributions that consider the interactions between city and national scales (Cowell, Ellis and Strachan, 2017).

Demand for heating accounts for a significant portion of global energy demand. In the EU final energy demand for heating exceeds that of electricity or transport, accounting for half of total energy (European Commission, 2016). Despite this 75% of the fuel used for heating and cooling in the EU comes from fossil fuels (International Energy Agency, 2014a).

Increasingly there is recognition that greater attention needs to be paid to heat decarbonisation. Not least because the decarbonisation of heat (and transport) has not been keeping pace with decarbonisation in the electricity sector (Carbon Connect, 2015; UNEP, 2015; Committee on Climate Change, 2018). Additionally there is growing awareness of the links and synergies between decarbonisation in the heat, electricity and transport sectors (Energy and Climate Change Committee, 2016; Deutsch Umwelthilfe, 2017).

Forecasts indicate that 75% of the European citizens will live in urban areas in 2020 and that this share will increase to 84% by 2050 (Connolly, Nielsen and Persson, 2013). This has significant implications for the decarbonisation of heat as action at the urban scale will be important in shaping the delivery of energy efficient buildings and low carbon heating.

At the same time there have been considerable changes in the economic position and climate leadership role of cities in many countries in recent years. For example, in the UK, government funding to local authorities reduced by an estimated 37% in real-terms from 2010-11 to 2015-16 and there is an ongoing move to refocus funding from a central settlement to the local collection of council tax and business rates (Lowndes and Mccaughie, 2013; National Audit Office, 2014). Over the same period the role of cities in climate governance has received greater attention, with the creation of a UN Special Envoy for Cities and Climate Change, the development of increasing numbers of city and sub-national climate governance networks, and the importance of sub-national implementation recognised in the 2015 Paris Agreement for Climate Action (Castán Broto, 2017).

Recognising the increasing profile of heat decarbonisation, together with the importance of local actors in delivering low-carbon heating technologies, this thesis seeks to explore the relationship between cities and the institutional framework for energy decarbonisation. It takes as its analytical focus the development of heat networks in England and Germany. Analysis of heat network discursive framings, actor networks and institutions is undertaken, together with a number of city case studies in each country, in order to explore the relationship between ideas and institutions. The two country contexts of England and Germany are selected as two settings which are currently seeking to expand the penetration of heat networks as part of decarbonisation strategies, but which exhibit differences in political economy, energy system history and policy approach to heat networks.

There is a growing focus in many countries on the role of heat networks in decarbonisation and, as outlined in chapters 2, existing literature has established that many of the obstacles to further heat networks development relate to the institutions, regulation and structure of the energy system. Heat networks are based on physical networks of pipes and network development invariably necessitates the involvement of a range of partners; commonly local authorities, other local public sector heat loads, commercial and industrial heat loads, energy companies and heat network developers/operators. These actor networks are complex and involve organisations operating across a range of scales. It is, however, unclear how actors at different scales engage in shaping, or are shaped by, the institutional structures relating to heat networks. This thesis explores this topic.

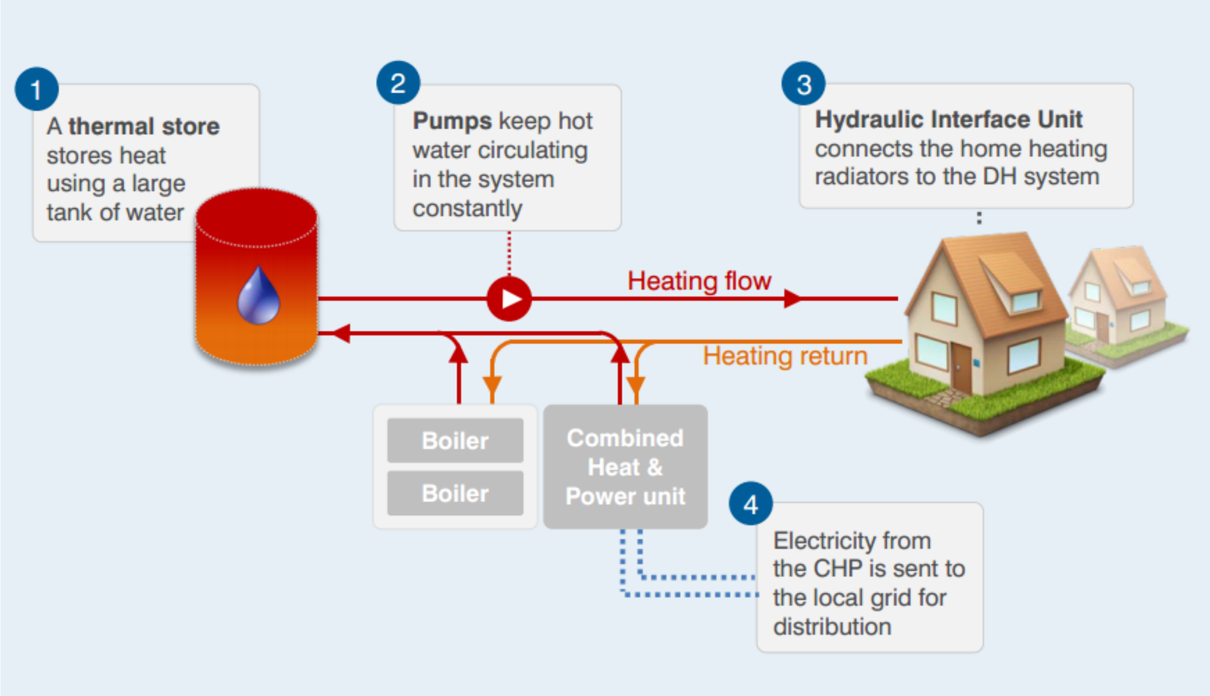
The rest of this introductory chapter outlines the rationale for the focus on heat networks, the conceptual and analytical approach adopted, research questions and details the key findings and contribution of the research. The final section introduces the structure of the thesis.

1.2 Heat networks

1.2.1 What are heat networks?

Heat networks, sometimes called district heating, comprise of networks of insulated pipes which transport hot (or cold) water or steam from the point of generation to end users, meeting residential and commercial needs for space heating, hot water and potentially cooling. As a result, individual buildings served by a heat network don't need their own boilers, chillers or air conditioners (UKDEA, 2014). In contrast to electricity supply, which is currently largely delivered by large, centralised electricity generation plants, heat networks are necessarily local infrastructure based on physical networks of pipes. Heat networks can be supplied with heat from a range of sources including heat recovered from power stations and industrial processes, waste-to-energy facilities, large-scale heat pumps, biomass combined heat and power (CHP) plants, gas-fired CHP units, electric boilers and solar thermal arrays. The systems usually consist of heat plants and a network of distribution and return pipes (CHPA, 2014). The structure of a typical heat network is illustrated in figure 1.

Figure 1: Typical structure of a district heat scheme.



Source: Parsons Brinkerhoff, 2014

Heat networks have a long history with early networks developed in the late 1800's in the United States. In Europe many cities developed small networks around a similar period but the first commercial systems tended to be developed in the early 1900's (Kelly and Pollitt, 2010; Magnusson, 2013). However, in Europe, it was not until the post-war period that development took off as the reconstruction of cities destroyed during World War II and rising social expectations regarding internal heating resulted in a large number of cities across Europe developing heat networks in the 1950's, 1960's and 1970's.

While district heat networks can use heat from a wide range of sources, networks are currently predominantly fuelled by gas-fuelled combined heat and power (CHP) (DECC, 2013b; UNEP, 2015). CHP integrates the production of usable heat and electricity, in a single, efficient process. It works by recovering heat from the power generation process and using it to heat domestic and commercial buildings as well as some industrial processes. CHP systems can deliver energy and carbon savings of up to 30% by reducing energy lost as waste heat compared to separate power and heat generation from the same fuel. In the OECD countries 79%[1] of heat networks utilise cogeneration and

[1] Based on 2011 data.

across Europe approximately 13% of total heat demand is met by heat networks (Euroheat and Power, 2013; International Energy Agency, 2014).

Although gas-CHP systems have lower emissions than separate power and heat generation, in order to meet the carbon emission reduction targets the heat sector in both the UK and Germany will need to be entirely decarbonised (DECC, 2011; BMWi, 2012). The UK Government (DECC 2013a) suggests that heat networks are compatible with decarbonisation targets provided that in the long-term gas is replaced by biofuels, carbon capture and storage (CCS) and large-scale heat pumps (powered by renewable electricity). Renewables based heat networks are not yet common however a number of Scandinavian heat networks are currently progressing plans to transition to operating on a 100% renewable basis, often incorporating thermal stores to reduce the demand for heat at times of peak electricity demand[2]. Additionally a number of energy system analyses (such as Chittum & Østergaard, 2014; Lund et al., 2010, Agora Energiewende, 2013) suggest that heat networks may be important to enable the cost-effective integration of low emission energy sources through providing balancing services. For example heat storage is technically unproblematic and heat can be stored or fed into district heating grids for at least a few hours without any major challenges. This can help to store excess electrical power, such as from wind power generation, in the form of heat for use at peak heat demand. Additionally heat networks can allow heat loads to be aggregated thus making sources of heat, such as waste heat or geothermal, economical.

1.2.2 How heat networks differ from other energy infrastructure

Although heat networks have been a small part of global energy systems for many decades there has been renewed interest in their role in energy system decarbonisation, as outlined in the following chapter. There has been particular focus on the ability of networks to incorporate various low carbon sources of heat and therefore be progressively decarbonised over time as different technologies become more economic. However heat networks also have a number of attributes that differ from the majority of other decarbonisation

[2] For example the Sunstore 4 project in Marstal which incorporates solar thermal, biomass, a heat pump and thermal storage.

technologies. For example other decarbonisation technologies tend to be either decentralised to the household level (heat pumps, domestic PV, energy efficiency) or connected to existing gas or electricity networks (wind, PV, EfW, biogas/hydrogen injection). In contrast, the development of heat networks generally[3] necessitate the concurrent development of generation, distribution and supply infrastructure, together with operational business models.

Additionally heat losses over large distances and the need to engage multiple local partners and consumer groups in development also means that networks tend to be developed at a local (or city-) scale. Heat network supply also does not conform to the liberalised model of energy supply dominant in European contexts as, once connected, customers are effectively supplied by a monopoly as the costs of installing alternative household-level heating technologies, such as a gas boiler or individual heat pump, are generally prohibitive.

Increased focus on heat networks and their different attributes to other heat decarbonisation options suggests that analysis of actor discourses and institutional approaches in different contexts, particularly between the local and national, may be useful to expand understanding of both the role of heat networks and also in the relationship between difference scales in energy transitions.

1.2.3 Heat network business models

Globally heat networks operate under diverse business models and regulatory structures (UNEP, 2015). Business models range from fully publicly owned systems, to public-private partnerships and cooperative models, to fully private systems. The relative involvement of the public or private sector depends broadly on three factors: 1) the degree of control each partner seeks to exert over project objectives, 2) the degree and type of risk project partners are willing to hold and, 3) the financial profile of a project, with structures negotiated by complex actor networks (Homes and Communities Agency, 2011; Rao *et al.*, 2017). Additionally, country specific norms relating to public and private sector

[3] In theory heat network generation, distribution and supply can be unbundled however unbundling was rejected in Sweden on the basis that it was likely to increase costs (Werner, 2017) and current networks in England and Germany tend to be operated on an integrated basis.

involvement in energy provision can also be significant in shaping business models (UNEP, 2015).

Analysis of heat network business models suggests that the wholly public business model is the most widely adopted globally (UNEP, 2015). Under this model local authorities or local public utilities retain full ownership and control of the network in order to deliver social and environmental objectives. The public sector holds the majority of the risk and either finances the project through reserves or borrowing. Projects may be developed within a local authority department or via a special purpose vehicle depending on returns and the approach to financial liability. Public business models which utilise public debt can result in higher rates of return due to reduced risks and a lower cost of capital (UNEP, 2015).

An alternative to full public ownership is a hybrid model which incorporate involvement of the public and private sector with control, risk and returns negotiated between partners. Hybrid models include:

- public and private joint ventures where both parties financing network development. The joint-venture model typically involves the creation of a special purpose vehicle (SPV) with both partners providing equity, and potentially debt, finance and the creation of a board which reflects the ownership split.
- concession contracts where the public sector is involved in the development of a project but then procures a private sector partner to design, build, finance and operate the network under a long-term concession. The models usually provide provision for the city to buy back the project at the end of the concession agreement. The concession holder bears the risks of designing, building and operating the district energy system but benefits from risk reduction through the involvement of the local authority in initial development and the provision of public sector anchor loads. Agreements may include requirements relating to charging structures or profit sharing but the local authority has limited control of the concession (Rao *et al.*, 2017).

- community-owned or cooperative business models. These schemes can be developed by communities with limited involvement of the municipality but in practice tend to closely involve local authorities in early development and potentially in financial underwriting.

Finally, heat networks can be developed under wholly private business models, although these tend to only be pursued when limited public sector coordination is required and the rate of return is sufficient to attract private investment. Such models are more likely to be pursued in new developments, rather than retrofit projects, where pipework installation costs are lower.

A broad categorisation of business models for heat networks as wholly public, hybrid public-private and wholly private is illustrated in table 1 below.

Table 1: Categorisation of business models for heat networks (UNEP 2015)

FINANCIAL RETURN ON INVESTMENT	DEGREE OF CONTROL AND RISK APPETITE OF PUBLIC SECTOR	TYPE OF BUSINESS MODEL	EXAMPLES
LOW	↑ High	Wholly public	■ District energy to meet social objectives related to housing or fuel poverty
MEDIUM / LOW	↑ High	Wholly public	■ Public sector demonstrating the business case of district energy systems ■ Public sector looking to create projects that will improve its cash flow ■ Public sector lowering the IRR by allowing cheaper energy tariffs than the private sector would
MEDIUM / HIGH	→ Medium	Public/private hybrid	■ Public/private joint venture ■ Concession contract ■ Community-owned not-for-profit or cooperative
HIGH	↘ Medium / Low	Private (with public facilitation)	■ Privately owned project with some local authority support, perhaps through a strategic partnership

1.4 Research questions and theoretical approach

It is argued in this research that the role of sub-national governance is under-explored in analysis of socio-technical change in energy systems. Given that local actors, particularly local authorities, are likely to be central to the development of heat networks greater consideration of city-scale interactions, process of negotiation and development, and the interplay between local-scale projects and wider national and international regimes, is likely to contribute to understanding of both energy transitions and socio-technical change more broadly. As the focus of this research is on the interactions between complex actor networks and processes of policy development at local and national scales, a discursive institutional approach to the development of heat networks is adopted. The research presents a conceptual framework which combined literatures related to transitions, ideas and institutions, and applies it empirically.

In this research a series of six case study locations are explored in the two country contexts of England and Germany. The specific research questions explored are:

- How are heat networks developing in England and Germany?
    - Which public and private actors are engaging in this scale of energy provision and why?
    - What storylines and discourses are being adopted by actors in the development of heat networks?
    - What discourses are dominant in the different contexts?

- How are heat networks engaging with, and potentially influencing, wider national and international transition processes?
    - How do wider governance structures (rules, incentives and norms) influence the development of heat networks in different contexts?
    - How do city-scale heat network projects interact with national policy and institutions?

- What role do city-scale actors play in shaping the ideational and institutional framework for heat networks in England and Germany?

1.5 Key findings

An overarching finding of this research is that there is a growing narrative at the local scale of the need for local governments to adopt more direct forms of governance in order to secure wider public good benefits of energy infrastructure, at least in the case of heat networks. This was evident in both country contexts and across cases. In developing heat networks all locations were adopting multiple roles but there was increased focus on ensuring modes of governing. Drawing on the work of Bulkeley and Kern (2006), these findings both (1) provide an empirical demonstration of the multiple modes of governing adopted by local governments in relation to energy transitions, and (2) challenge Bulkeley and Kern's (2006, p. 2240) assertion that the UK and Germany are converging on a more partnership based ‘ensuring’ model of climate change governance. While an ‘ensuring’ discourse was more explicit in the case study locations of Bristol, Frankfurt and Hamburg (as the three cases adopting municipal ownership of heat supply) it was also evident in a more muted form in the other three cases (Rhein Hünsruck, Sheffield and Birmingham) in the form of increased debate regarding control of networks and the balance between local benefits and risks.

Currently much discursive institutional literature presents ideas as influencing policy outcomes only when fully formed (Carstensen and Schmidt, 2016; Gillard, 2016), however, this research suggests that emerging, chaotic and conflicting ideas can also be powerful. Ideas relating to an ensuring state and ‘remunicipalisation’ were being used in a variety of contexts (electricity generation, energy supply, power networks, heat networks) to illuminate broader trends regarding the localisation of energy systems and the potential role of local authorities in delivering multiple local benefits. However, despite these local ideational shifts, institutional norms and wider governance traditions persisted which were limiting the ability of local governments to enact a more central role in energy systems. Specifically a lack of institutional structures to include local authorities in energy policy debates and a national norm of ‘enabling’ modes of urban climate governance (particularly in England) acted to limit the ability of local authorities to translate the ideational power they were exercising within their organisation and with peers (*power through ideas*) into influence on national policy. This highlights the ability of ‘power in ideas’, exercised through national norms and policy making processes, to constrain other types of ideational power – particularly those that originating from local actors.

Although local and national historical factors are revealed to be important the findings highlight that historical institutional accounts of the development of heat networks in England and Germany are not sufficient. The two countries have very different histories (in terms of heat network growth, institutional links between local and national scales and the strength of devolution and austerity discourses) but similar discourses were evident in relation to an ensuring role for local government, increased interest in direct ownership and the need to deliver multiple objectives. This incremental framing highlights the importance of 'background' discursive processes and frames processes of change as incremental and dynamic. In England in particular interlinked economic, political, technical decentralisation trends were, together, creating the discursive space for local authorities to re-evaluate their role in relation to energy.

Finally, in relation to MLP literatures this study indicates that applying an DI approach to Geels *et al.*'s (2016) characterisation of shifts between transition pathways can provide a more detailed understanding of the role of endogenous (urban regime) processes in system change and illuminate the potential for differing transition pathways to be dominant at different scales at various points. In particular the national heat network pathway in England can be understood to align more with a transform pathway with the drive to develop new heat decarbonisation strategies allowing incumbent actors to argue for incremental policies which support financial de-risking and regulate heat networks in line with existing energy networks (layering). At the local level pathways aligns more closely to reconfiguration with a range of changes to ideas within the urban energy regime combining to allow (some) local authorities to transform their local approach (displacement), albeit with little change to the national system architecture. Applying a DI approach to understanding ideational power and bricolage allows for the examination of the processes by which competing discourses and ideas, at different scales, can influence transition pathways.

1.6 Structure of the thesis

Following this introduction chapter 2 reviews the history, current status and likely future development of heat networks in England and Germany. This includes an overview of the role of local governments in energy systems in the two countries and an assessment of the core challenges in further developing heat networks. The key barriers identified relate to the co-ordination of complex actor networks at a city scale, the development of appropriate financing, ownership and governance structures, lack of integration of district heating into the current energy system structures and energy system governance that does not support district heating.

Chapter 2 also establishes that policy relating to heat networks is in a period of flux in both countries and receiving increased policy attention. A range of actors are involved in development and there are a number of possible future governance routes, with local authorities likely to play a significant role in most networks. This central but uncertain role for local authorities, together with the complex barriers identified, suggests that the development of heat networks is likely to be a highly contested process with a number of actors and interests seeking to influence the direction of development. To further contextualise heat networks in the energy system, chapter 2 also includes a short overview of heat networks across Europe.

Chapter 3 outlines the theoretical framework which is adopted in the research. The study seeks to examine the role of the city-scale in processes of change in socio-technical systems and it is argued that there is a particular gap in the transitions literature relating to the conceptualisation of regime politics at sub-national scales. This has resulted in limited consideration of the role of different actors at the city scale, process of negotiation and development, and the interplay between local-scale projects (such as heat networks) and wider national and international regimes. A discursive institutional approach to the development of heat networks is therefore proposed to explore these issues and the research presents a conceptual framework which combined literatures related to transitions, ideas and institutions, and applies it empirically. This approach is likely to be particularly appropriate in light of the findings of chapter 2 that many of the obstacles to heat networks relate to the institutions, regulation and structure of the energy system.

The overall methodological approach involved three main stages: (1) a review of national heat network policy and discourses in England and Germany; (2) a review of the development of heat networks and associated discourses in three case study location in England and three case studies in Germany; and, (3) a series of in-depth interviews with a range of local, national and international actors involved in heat network development and delivery. Chapter 4 presents the detailed methodology and analytical approach adopted in the research. This consists of analysing national contexts and city case studies in relation to the three levels of ideas identified by Vivian Schmidt (2010); policy ideas, programmatic ideas, and philosophical principles. In order to explore the relationships between ideas and institutions, the work of Hajer (2006) is drawn upon to structure the analytical stages and identifies key discourses, actor networks/coalitions, and the institutional practices in which discourses are produced.

Chapters 5 and 6 present and analyse the results of the empirical research carried out in England and Germany respectively. This includes exploration of discourses and actor networks, discourse structuration and institutionalisation. Both chapters start with a summary of heat network development in the case study locations of Bristol, Birmingham, Sheffield in England; Hamburg, Frankfurt and Rhein Hünsruck in Germany. The chapters then analyse problem definition discourses, key established and emerging storylines, coalitions and discourse structuration and interactions between discourses and institutional structures.

Chapter 7 integrates the findings of chapters 5 and 6 and examines the ideational framing of the key discourses identified in terms of policy, programmatic and philosophical ideas. In order to explore how ideas become influential and shape institutions processes of ideational power (power over, in and throuh ideas) are discussed with ideational bricolage revealed to be an important process in allowing local actors to reconceptualise their role in energy system change and resist national institutional norms.

The final chapter presents responses to the six research questions that are the focus on the research and clarifies the contribution of the work to debates of energy system change with specific contributions identified in relation to urban governance literatures and the application of discursive institutionalist approaches. The utility of applying a DI approach to explore regime interactions within the MLP is also discussed. The chapter concludes by discussing the policy implications of the findings, highlighting some limitations of the research and making some recommendations for future work in this area.

Chapter 2: Heat networks in England and Germany: overview and policy context

2.1 Introduction

This chapter reviews the history and development of heat network policy in England and Germany, the role of local authorities in developing networks and the barriers to deployment. Changes in the governance framework for local authorities are outlined, together with the potential relevance of this for heat networks. A number of core challenges in further developing heat networks are identified relating to the co-ordination of complex actor networks at a city scale, the development of appropriate financing, ownership and governance structures, lack of integration of heat networks into the current energy system structures and energy system governance that does not support heat networks. This chapter establishes that heat network policy is receiving increased policy attention as part of decarbonisation strategies in both countries, with policies in particular flux in England. Heat networks generally involve a wide range of actors, which may be brought together under a variety of governance structures, with local authorities likely to play a significant role in most networks.

Section 2.2 starts by giving a summary of heat networks in Europe. Section 2.3-2.5 then presents an overview of heat policy and heat network development in England. This includes the role of local authorities together with how changes to local governance structures might be relevant to heat network development. Section 2.6 presents a similar outline of heat network development in Germany and the role of municipalities. Section 2.7 reviews the literature on the key barriers to heat network growth and section 2.8 concludes and links the findings of the chapter to the focus of this research.

2.2 Heat Networks in Europe

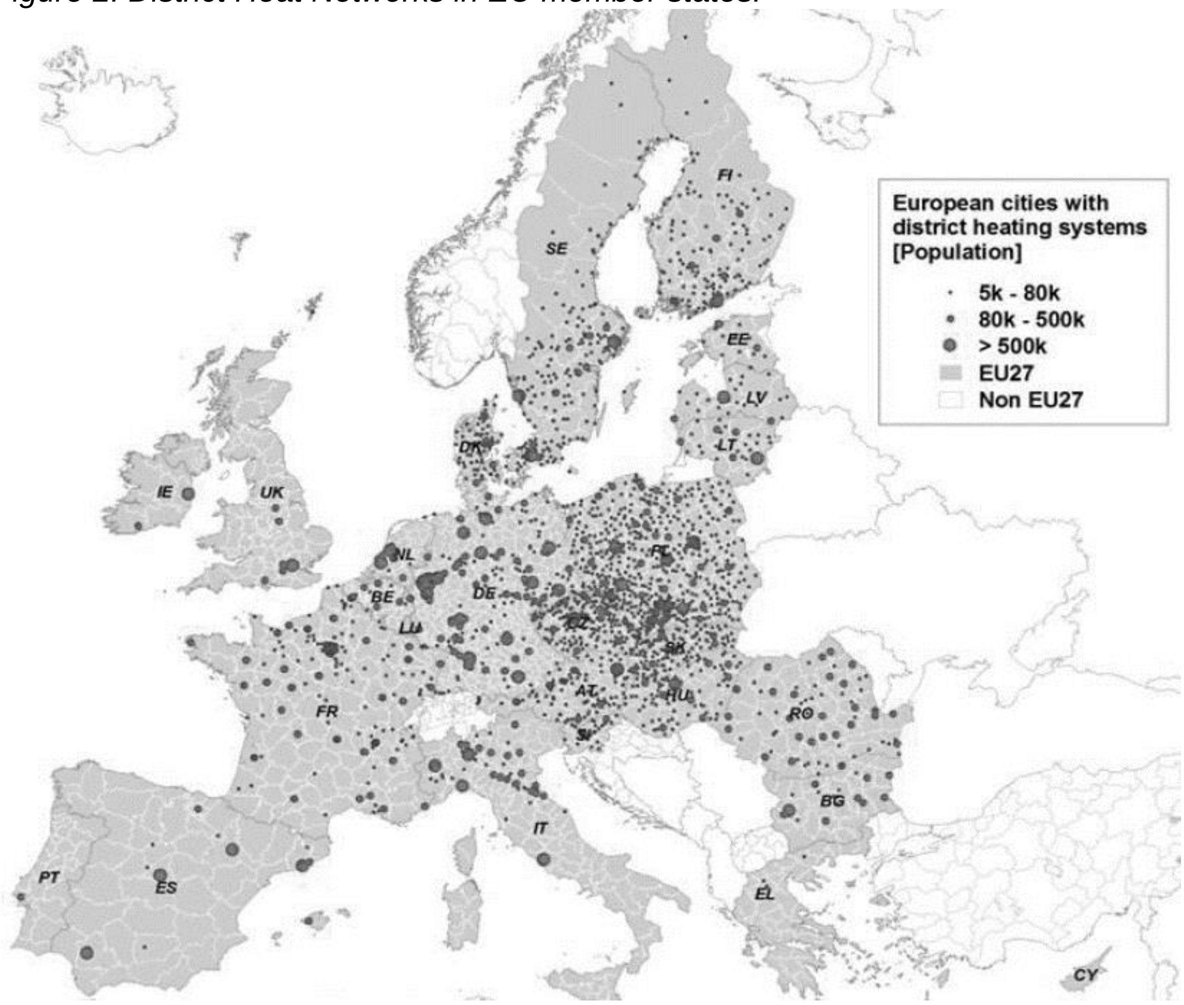
Heat networks are widely used across many European countries[4] with

[4] In addition to considerable recent growth in other countries. China and Russia have the world's largest networks, although they often have lower efficiencies and higher emissions than European networks, and China has the fastest growing networks with heat network sales increasing by 25% between 2007 and 2011. The United States has the greatest reported district

250GWth of installed heat network capacity meeting 9% of heat demand across the European Union (EU) and supplying approximately 13% of the EU population (Euroheat and Power, 2013; Heat Roadmap Europe 2050, 2017b). As illustrated in figure 2, the level of deployment of heat networks varies considerably across Europe, however approximately 6,000 systems are in operation across the EU member states (Connolly *et al.*, 2014)

Heat networks are particularly well established in many of the Northern European countries where, for example, heat networks account for 63% of the heat market in Denmark, 50% in Finland and 24% in Austria (Energy Technologies Institute, 2012; Committee on Climate Change, 2014; Euroheat and Power, 2015).

Figure 2: District Heat Networks in EU member states.



(Euroheat and Power, 2013)

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cooling sales and district cooling capacity tripled in South Korea between 2009 and 2011 (International Energy Agency, 2014; Euroheat and Power, 2013).

Historically, beyond energy efficiency, there has been little focus on heat decarbonisation policy at the European level (International Energy Agency, 2014), however more recently there has been renewed focus on both the need to decarbonise heat and the potential role of heat networks. The 2016 European Commission strategy on heating and cooling included a joint focus on renewables and heat networks and a number of studies have highlighted the need to link the heat and electricity systems (European Commission, 2016; Riahi, 2016). This includes several European studies which indicate that the lifetime costs of CHP heat networks are competitive with alternative heating systems (Oñate, 2013; International Energy Agency, 2014) and that increasing the penetration of heating and cooling networks to 30% by 2030 and to 50% by 2050 across the EU is essential to achieve decarbonisation and cost goals (Connolly, Nielsen and Persson, 2013).

Similarly the United Nations Environment Programme suggest that heat networks are undergoing a resurgence due to their ability to integrate high penetrations of variable renewable energy sources and thermal storage (UNEP, 2015). This focus on an important role for heat networks in decarbonisation is echoed by the International Energy Agency who describe heat networks as 'fundamental for decarbonisation' and able to 'serve as a backbone to facilitate the diffusion of low-carbon technologies, and provide co-benefits to the rest of the energy system' (International Energy Agency, 2012: 175-6).

Although this increased profile for heat networks in EU energy policy is a recent development the EU has aimed to increased CHP capacity for many years, recognising the efficiency and greenhouse gas emission benefits of the technology. In the early 2000's the European Commission set a goal to double CHP electricity production from 9% to 18% of total EU electricity production by 2010. The target of 18% CHP production was missed and the current share is about 12% (Eurelectric, 2014). More recently the 2012 EU Energy Efficiency Directive included provisions to promote CHP such as the requirement that each EU country carries out a comprehensive assessment of the national potential of cogeneration and district heating and cooling. Between 2003 and 2013 the European Commission's Intelligent Energy Europe (IEE) programme, which aimed to support EU energy efficiency and renewable energy targets, supported a number of heat network projects, this included capacity building, policy support and technical support in developing bankable heat network schemes (Intelligent Energy Europe Programme, 2014). Similar support is currently available through the Horizon 2020 funding programme. Beyond this heat networks and CHP are largely promoted through national energy, climate, environmental and fiscal policies including support via feed-in systems, investment support, tax breaks and grants. For example in Denmark a feed-in-tariff has been paid to decentralised CHP plants since 1992, in Sweden a combination of carbon taxes, subsidies and low-cost loans are utilised to support heat networks, and in the Netherlands there is a feed-in-tariff for CHP electricity (Frontier Economics, 2015).

Heat networks also operate under a wide range of governance and ownership structures across Europe, including 'centralised state provision, through ministries and state-owned companies, local municipalities and private provision' (Helm, 2010). However, in much of Europe local authorities have usually played a crucial role in establishing heat networks and the dominant governance model for heat networks has been via locally-owned energy companies with the municipal authority as a significant shareholder or owner (Hawkey & Webb, 2012; Ericsson, 2009). Likewise differing regulatory styles across Europe have led to heat networks being regulated in widely different ways. For example, in much of Eastern Europe there is an expectation that CHP operators will use revenues from electricity sales to lower heat prices. In some countries this includes ex-ante price regulation of heat prices and returns, such as in Latvia, Romania and Poland (Eurelectric, 2014).

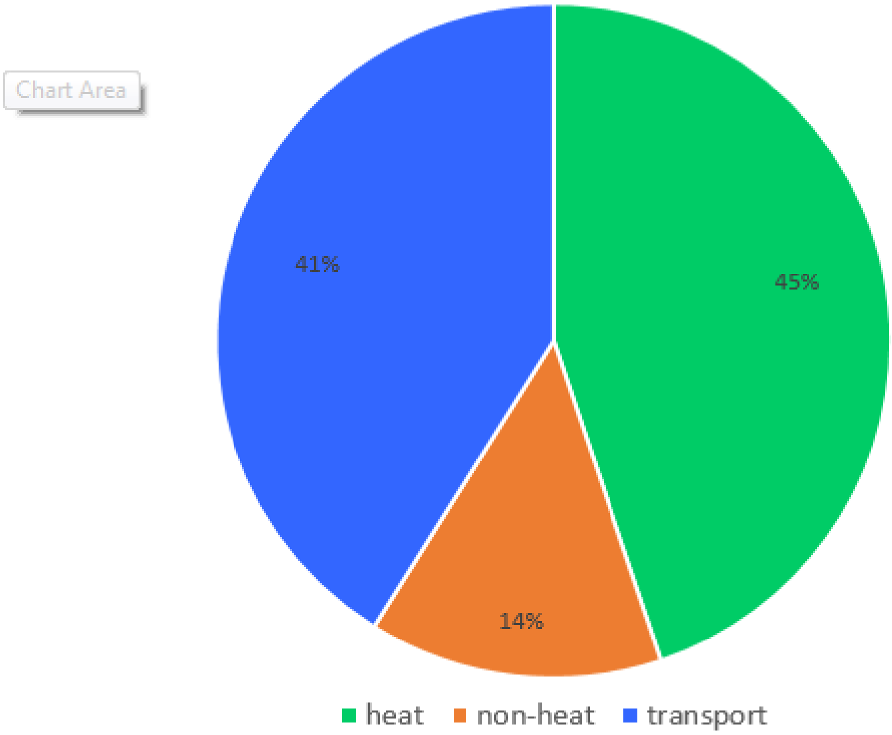
2.3 Heat Policy in England

In the UK[5], heat energy currently makes up 45% of final energy consumption, accounting for 38% of carbon emissions, see figure 3 (BEIS, 2016a, 2017b). Meeting the UK's ambitious greenhouse gas (GHG) emissions target(s), of

[5] The focus of this thesis is on the development of heat networks in England and Germany. However much of the policy analysis and data relating to heat networks relates to the UK as a whole rather than England specifically. Where this is the case UK wide information is used and clearly referred to as UK data.

reducing greenhouse gas emissions by 80% by 2050 against a 1990 baseline, will therefore require very significant cuts in emissions from heat. This is particularly the case as the Government has indicated that, in line with Paris Agreement commitments, it intends to set a UK target for reducing domestic emissions to net zero in the future (Committee on Climate Change, 2016b). Reducing greenhouse gas emissions from heating can be achieved both by reducing heat use through energy efficiency, and by reducing the emissions intensity of heating through the adoption of low and zero carbon heat technologies (NERA and AEA, 2010).

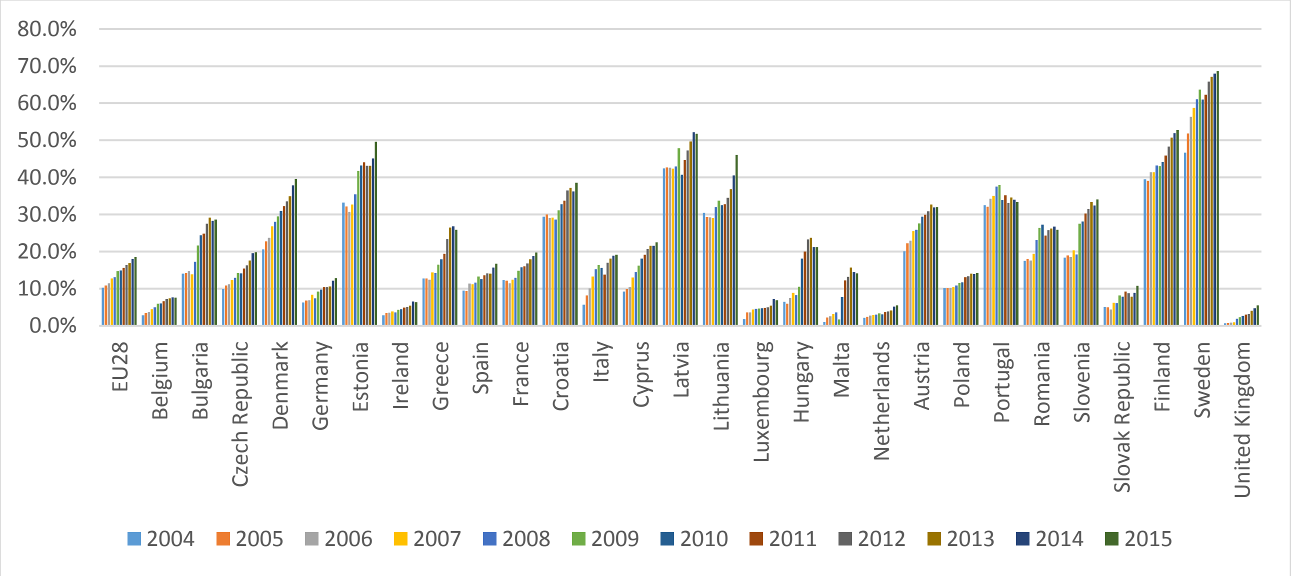
Figure 3: Energy consumption for heat, non-heat and transport, 2016



Source: (BEIS, 2017b)

To date there has been a low penetration of renewable heat in the UK compared with much of the rest of Europe, as outlined in figure 4. Instead heating in the UK is dominated by gas, with building-level gas boilers accounting for 68% of heating systems in the UK (see figure 5). The dominance of gas boilers in the UK results from a number of historical factors, including the UK's access to cheap North Sea gas, the development of a national gas grid, and comparatively low access to other indigenous heat sources, such as biomass or geothermal. Heat can, however, be delivered to customers via a variety of alternative low carbon methods including; an individual heating system fuelled by renewable gas (biomethane or hydrogen), an individual heating system not connected to a networked fuel supply (such as a biomass boiler or solar thermal), electric heating (including heat pumps) and heat networks that supply heat through pipework carrying hot water or steam[6].

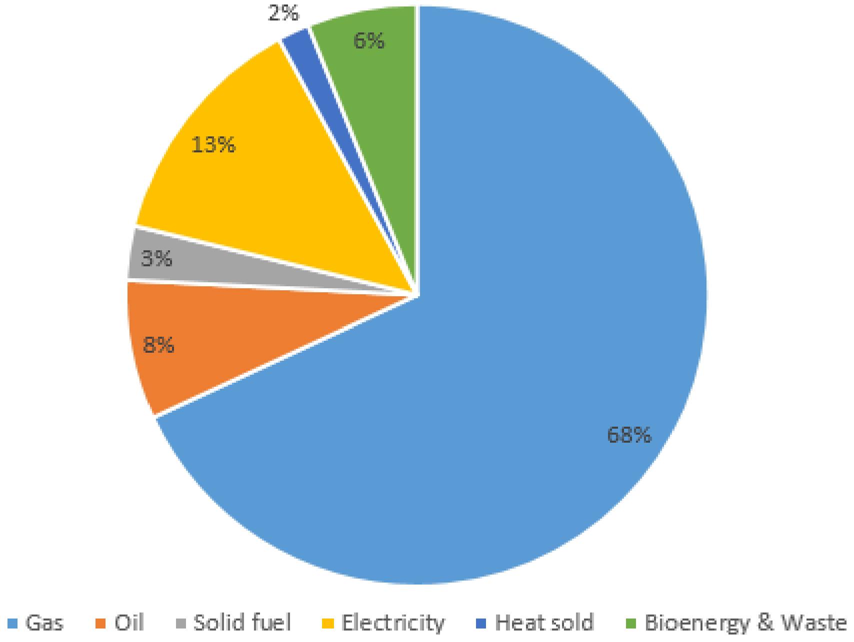
Figure 4: Percentage of heating and cooling from renewable resources as a percentage of total energy used for that purpose – EU28, 2004-2015.



Source: (Eurostat, 2017)

[6] Heat networks are a heat supply, rather than generation, technology and therefore their carbon emissions depend on the emissions of the associated heat generation technology. However it is possible to substantially or completely reduce carbon emissions from heat through the use of renewably-fuelled heat networks.

Figure 5: Breakdown of heating systems across all UK buildings, 2016



Source: (BEIS, 2017b)

To date UK Government scenarios have suggested that heat will largely be decarbonised through widespread electrification of heating systems, principally with the use of heat pumps, leading to a policy focus on measures to decarbonise electricity (DECC, 2013b). However reliance on the electrification of heat poses a number of problems, including the likelihood that much of the existing gas infrastructure will cease to be used and the need for major change in consumer practice and heating installer supply chains (Hoggett, Ward and Mitchell, 2011). Significantly, a large scale transition to heat pumps could also require approximately 40GW of additional electricity generation capacity in order to meet peak heating demands (Eyre & Baruah, 2014).

Increasingly government and industry experts have been recognising that a diverse portfolio of technologies are likely to be important to the decarbonisation of heat; including energy efficiency, heat networks, electrification and decarbonised gas networks, although the relative role of each technology is still subject to much debate (Chaudry *et al.*, 2014). This uncertainty regarding deployment levels of low-carbon heat technologies, together with analysis which suggests that progress in decarbonising heat is not sufficient to meet future carbon budgets (Committee on Climate Change[7], 2014; Connect, 2015; Verco, 2014), have added to a growing recognition amongst policymakers that policy to decarbonise heat requires more attention. This has led to a recent resurgence of interest in heat policy in the UK and recognition that alternatives to electrification, including heat networks, are likely to play an important role. Indeed recent analysis has highlighted that 56 per cent of GB building heat demand is concentrated within only four per cent of the geographical area, indicating that there is significant potential for heat networks in relation to a large proportion of heat demand (AECOM and ETI, 2017).

2.4 Heat networks in England

Heat networks remain uncommon in the UK, accounting for approximately 2% of total heat demand (DECC, 2013a; ADE, 2018a), although there is some variation in estimates due to a lack of robust datasets collating information on all networks. The Government has estimated that there are around 2000 networks serving approximately 210,000 dwellings and 1700 commercial and public buildings (DECC, 2015a), whereas the Association for Decentralised Energy (ADE) has more recently estimated that there are 17,000 heat networks[8] with over 490,000 connections[9] (ADE, 2017b).

Despite their low penetration, heat networks have a long history in the UK and their development can be characterised as progressing through four broad phases, as detailed in figure 6. Initially, first generation schemes were developed in the UK in the late 1800's and early 1900's (Kelly & Pollitt, 2010) often with municipal authorities taking a role in their development and operation (Hall, 2003). Second generation schemes were developed in the inter- and post-war period between 1930 – 1980 and third generation plants, which more commonly incorporate renewable sources of heat, are currently under development. Over these three phases the structure of the UK energy system has also changed significantly including the reorganisation of municipal energy

[7] The CCC particularly highlight that progress on energy efficiency, low-carbon heat and electric vehicle deployment is insufficient to meet carbon targets.
[8] Of which around 91% are located in England, 6% in Scotland and 3% in Wales.
[9] Including 446,517 domestic customers, 33,273 commercial customers, 4,670 retail customers, 320 light industrial customers, 1,456 universities and school and a further 4,865 mixed use networks.

companies into central and regional boards in the 1920s, the renationalisation of energy generation and supply following World War II and the liberalisation and privatisation of the energy system through the 1980s and 1990s (Russell, 1986). Fourth generation heat networks which utilise lower temperatures, renewables and integrate with the smart electricity grid are expected to develop from 2020.

In the UK and across Europe, heat networks were first used in urban areas. In the UK there was also considerable growth in the use of heat networks when high-rise housing developments were built in the 1960s and 1970s, and many of the schemes in operation today in the UK originate from this period. Following this period of growth heat networks fell out of favour for a number of reasons, including the waning popularity of high-rise housing developments during the 1980s and 1990s. Additionally as Chaudry *et al.* (2014) highlight the poor design, construction and economic performance of some 1st and 2nd generation plants in the UK may have impacted on perceptions of current (3rd generation) heat network projects. Often these poorly maintained schemes were based on large council housing estates and focussed on heating domestic, social housing.

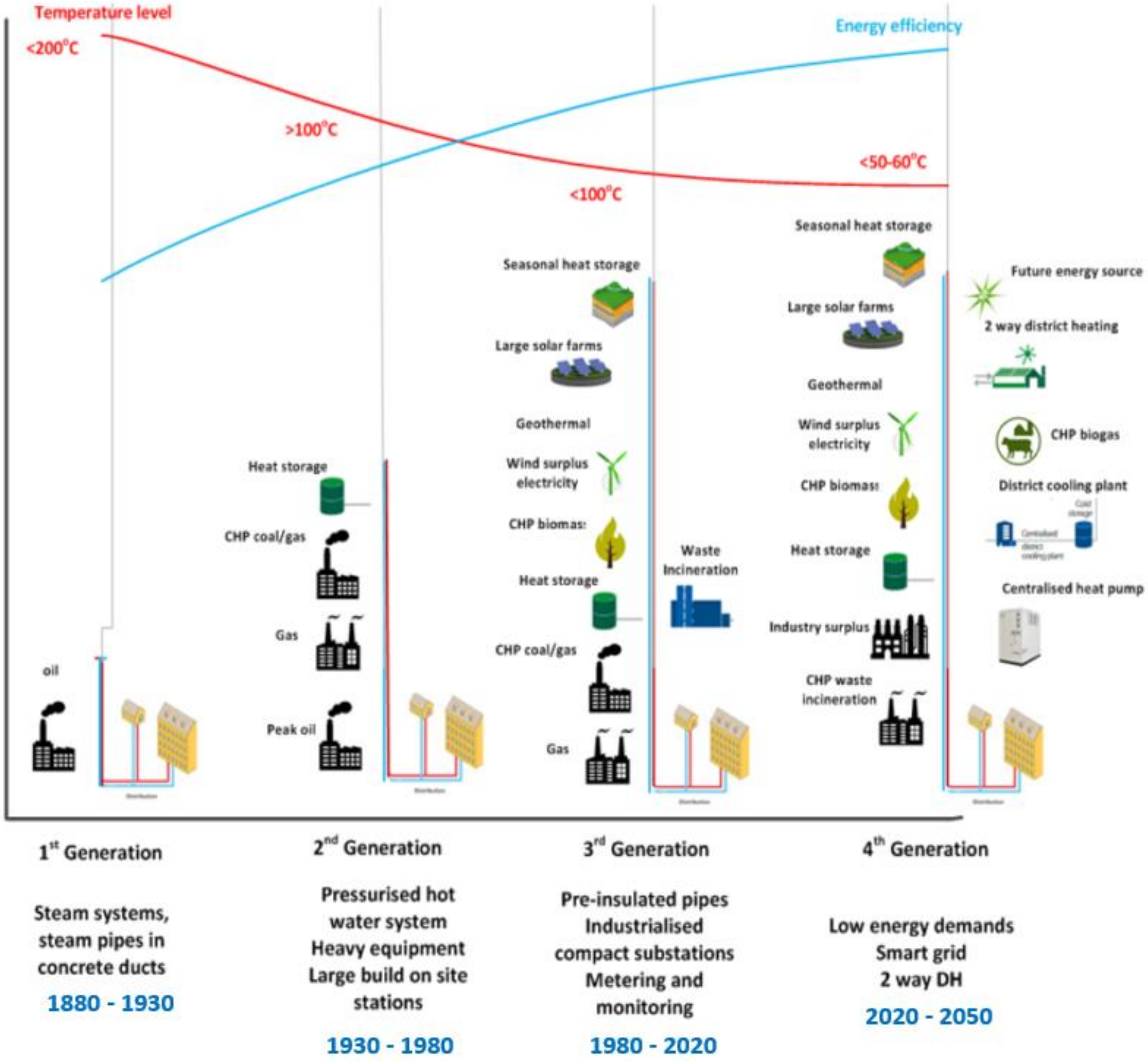
Over these extensive phases of development there was periodic interest in whether heat networks (and CHP) would emerge as a significant technology in the UK energy system with proponents pointing out the increased efficiency and energy security benefits of such systems[10]. Despite this intermittent interest Russell (2010) argues that a number of factors have limited the development of heat networks. Firstly, the period following World War II saw a focus on providing increasing quantities of energy, at low prices, to feed economic growth (Rydin et al., 2013). Centralised provision, economies of scale and the development of the national transmission system were seen as the most effective way to do this leading to a policy focus on large scale electricity systems and a marginalisation of more locally based heat networks. During this phase, when energy generation, distribution and supply were nationalised in the UK, there was a focus on centralised producer interests and limited local

[10] Particularly following the oil shocks of the 1970's

authority power in the energy sector which further dis-incentivised expansion of heat networks (Russell, 1993).

Secondly, from the 1980's onwards successive UK governments focussed on a neo-liberal approach to economic governance which treated privatisation of public assets as a means to improve cost efficiencies, reduce public expenditure and stimulate growth (Helm, 2010). This led to the privatisation and liberalisation of the energy system in the 1980's and 1990's and the introduction of a new market logic focussed on short-term returns that has not supported the development of heat networks due to their long paybacks and high capital requirements. The emphasis of the liberalised energy system on competition and consumer choice also means the long-term energy contracts essential for most heat network viability are unusual, particularly in the domestic sector. Thirdly, in the 1990's, as climate change concerns started to influence policy, Kelly & Pollitt (2010) highlight how policy developments, such as the failure to establish a market for heat (as was the case for electricity), the exclusion of CHP from the Non-Fossil Fuel Obligation (NFFO) and the withdrawal of the obligation for industry to explore CHP potential, further limited the potential of CHP heat networks to expand.

Figure 6: Evolution of district heating networks



(Adapted from Chaudry *et al.*, 2014; Lund *et al.*, 2014)

2.4.1 Heat network growth scenarios

A number of studies have assessed the potential role for heat networks in the decarbonisation of the UK energy system. These studies generally took a scenario approach based on the techno-economic feasibility of heat networks across the country, and resulted in estimates of between 3%-43% of space and hot water demand potentially being able to be met by heat networks, as outlined in table 2.

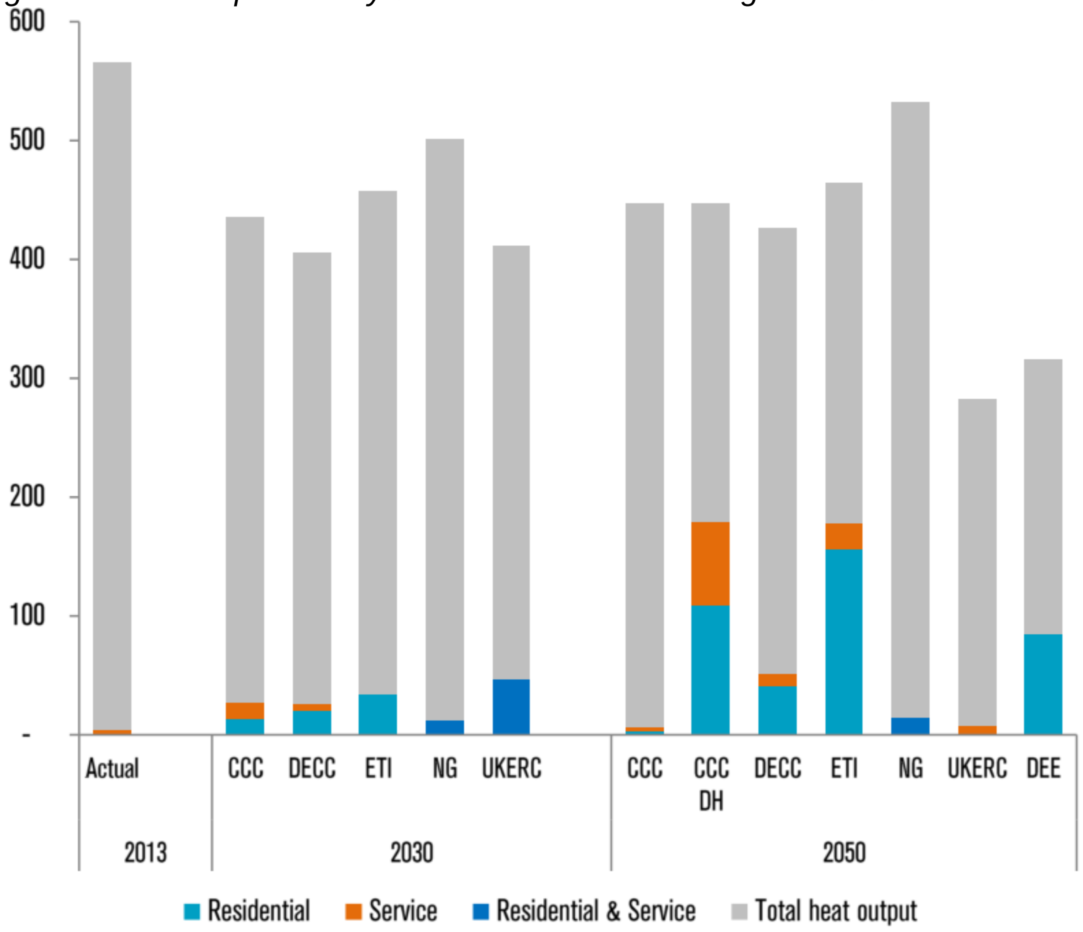
Table 2: UK heat network feasibility studies

Organisation	Year	Potential identified
Poyry Energy and Faber Maunsell (on behalf of	2009	Potential to connect 3 to 8 million homes and 15 to 26 million metre²

DECC)		of commercial and public buildings. Concluded that up to 14% of heat demand could be met through heat networks by 2050.
Delta EE	2012	34% of homes adopt heat networks under the ‘Electrification and heat networks’ scenario. 27% of homes adopt heat networks in the ‘Balance Transition’ Scenario.
Energy Technologies Institute	2013	Suggests that 43% of the current British building heat market can be economically connected to macro district energy schemes.

In addition to these specific heat network feasibilities most whole system energy models identify a role for heat networks in UK energy system decarbonisation. The outputs from these models vary greatly, ranging from scenarios where heat networks increase only marginally to growth in line with the higher end of the ranges indicated in the feasibility assessments in table 2 (40%+ of building heat). The role identified for heat networks in these models in 2030 and 2050 is summarised in figure 7.

Figure 7: Heat output met by district heat across a range of models.



Source: (Carbon Connect, 2014)

Key: Figure 7 refers to the following models:
CCC DH = Committee on Climate Change. Fourth Carbon Budget Scenarios; High district heat variant
CCC = Committee on Climate Change. 4 Carbon Budget Scenarios; stretch scenario for heat for buildings
DECC = Department of Energy and Climate Change. Partial energy system model.
ETI = Energy Technologies Institute. Energy system model, 2013.
NG = National Grid, Future Energy Scenarios, 'Gone Green' scenario
UKERC = UK Energy Research Centre, Phase two scenarios: 'Low Carbon' 2013
DEE = Delta EE for Energy Networks Association. 'Balanced Transition' scenario, 2012.

As table 2 and figure 7 indicate there is considerable variation in projections of the future role of heat networks in the UK energy system. This is partly accounted for by differences in methodology and scope but is also a factor of the difficulty in representing heat networks in system models which tend to lack a geographic dimension. In particular the studies differ in terms of the level of spatial detail, timeframes and underlying assumptions, including the role of gas in heat networks, what heat densities make heat networks cost-effective and how costs relating to gas, renewable technologies and heat network pipes change over time (DECC, 2013b).

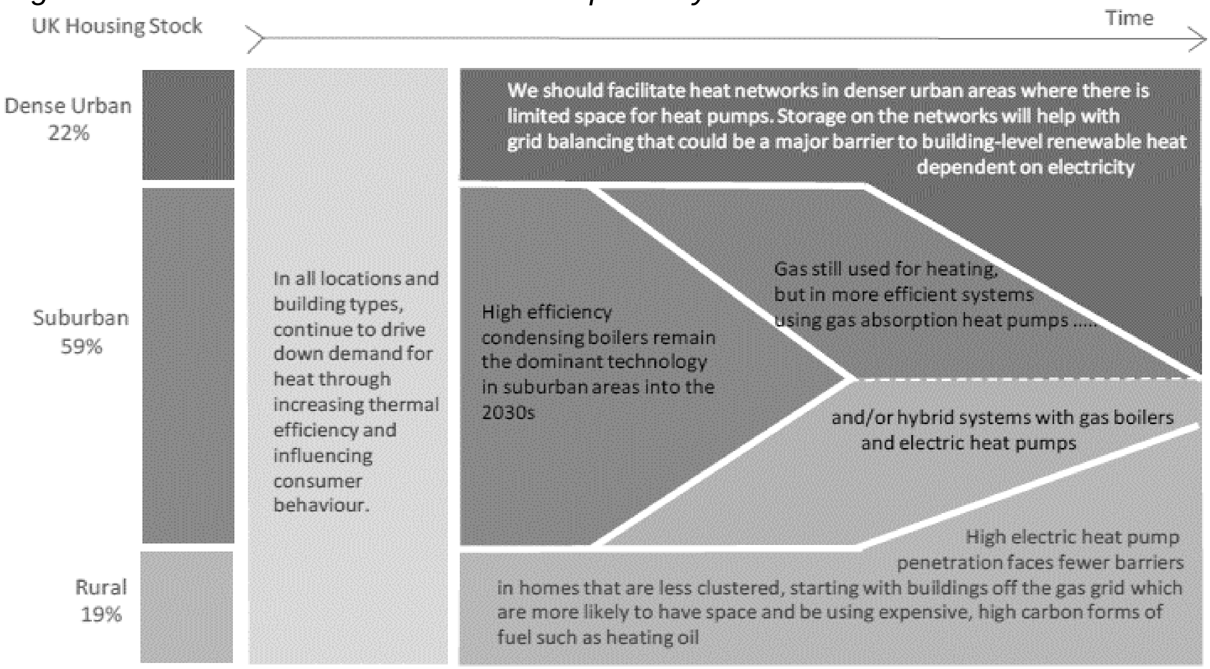
Energy system models have historically focussed on national electricity and gas supply and energy efficiency with little recognition of the potential for local heat distribution in decarbonisation scenarios (Connolly et al., 2014; Persson et al., 2014). For example the Europe Commission's Energy Roadmap 2050 report focusses on electrification of heating and energy efficiency measures and none of the six scenarios involve the large-scale implementation of heat networks (European Commission, 2012). However, energy system modelling by Connolly et al. (2014) suggest that a new 'district heat plus heat savings' scenario should be considered and that this approach could achieve the same reductions in primary energy supply and GHG emissions but at a lower cost than electrification and energy efficiency alternatives. Under a 'district heat plus heat saving' scenario 2050 heat decarbonisation targets are achieved through a combination of heat networks in cities (50% penetration), heat pumps in rural areas (50% penetration) and 30-50% total energy reduction, resulting in €100billion/year lower costs than the European Commission's deep energy efficiency scenario.

2.4.2 The developing policy landscape for heat networks

Over the last 30 years various financial incentives and support schemes have been developed to drive deployment low-carbon energy technologies in the UK. Whilst few of these have been specifically aimed at heat networks a number of them, such as the Climate Change Levy, Renewable Heat Incentive (RHI) and Enhanced Capital Allowances interact with heat networks (Connor *et al.*, 2015). These past policy measures are outlined in appendix 1 and this section details the current policy landscape for heat networks in England. The policy approach discussed in this section is then further analysed in chapter 5.

Over the past decade, as gas prices have risen and the need to concurrently address carbon reduction and fuel poverty concerns has increased, the case for heat networks has strengthened (DECC, 2013b). There is increasing interest from UK policymakers and analysts in their potential role in decarbonisation, most clearly with the 2012 publication of a 'Strategic Framework for Heat', followed a year later by more detailed analysis in the ‘Future of Heating’ (DECC, 2012; 2013a). These documents set out high level priorities across the heat sector and projected a significant increase in the (urban) role of heat networks to 2050, as illustrated in figure 8. The 2013 strategy suggested that, provided they can be used to distribute heat from low carbon sources, heat networks can be core to the UK’s heat strategy and have the potential to play a ‘critical role’ in decarbonising both domestic and industrial heat supply to 2050. This aligns with a range of literature that that suggests that heat networks are likely to become increasingly important in the energy system (Bolton, 2011; International Energy Agency, 2014).

Figure 8: Indicative heat decarbonisation pathway in the UK



Source: DECC, 2013a

In England these broad commitments have translated into some new policy support for heat networks consisting of the development of the Heat Network Delivery Unit (HNDU) and, more recently, the launch of the Heat Network Investment Project (HNIP). Additionally a number of industry led measures have been developed.

The HNDU was established in 2013 to provide financial and technical support to local authorities in the development of heat networks. The Unit has operated eight rounds of funding support since 2013 and has allocated £19million of grant funding to over 200 heat network projects across 140 local authorities in England and Wales (BEIS, 2019). Under the HNDU programme local authorities can apply for funding to support 67% of the external costs of heat mapping, master planning, developing technical proposals, financial evaluations, developing governance processes, project management and any other agreed works to allow the preparation of heat network investment documents, business plans and financial models. The HNDU team provide some direct support and advice to local authorities developing heat networks however the majority of support is in the form of funding to enable the appointment of consultants to compete feasibility assessments.

In the 2015 Spending Review the Government announced it will provide over £300m of funding for heat networks over the next five years (DECC, 2015d) in order to unlock up to £2bn of private investment and support heat networks which will heat over 400,000 homes. This funding was finalised as £320 million in 2016 (BEIS, 2016c) and a pilot stage Heat Networks Investment Project (HNIP) initiated. The pilot scheme launched in October 2016 and allocated £24.21m of funding to nine Local Authorities to develop or build heat networks. The funding was focussed on the commercialisation phase of development and grants and loans are available to support projects that have not been able to attract investment or where the internal rate of return is not sufficient to meet investor hurdle rates. New build networks, expansions, refurbishments and interconnections are all eligible for the funding and networks must generate heat from 75% gas CHP or from 50% renewable, recovered heat or a combination. Loan terms align closely to the ‘project life’, up to a maximum of 40 years and a low interest rate applies[11]. Only local authorities and other public bodies were eligible for the pilot stage funding, although these organisations can ‘on-invest’ in public or private heat networks (BEIS, 2017d). The main phase of the programme opened to applications in February 2019 and eligibility to apply for grants and loans expanded to include any public, private or third sector a wider set of heat network sponsors and/or owner-operators (BEIS, 2018b).

[11] Below Public Works Loan Board rates.

The HNIP builds on the government's Energy Networks report which it estimated that the heat network capital investment opportunity is between £400 – 800 million[12], based on 25 – 50% of the projects receiving HNDU support being built out (DECC, 2015c). This figure is based on England and Wales and excludes non-HNDU projects[13]. The Heat in the City project suggests incorporating these additional schemes could increase total investment to £1,000m by 2025 (Heat and the City Project, 2015). Broader government assessments suggest a total pipeline of in the region of 280 projects and suggest this will require up to £2 billion of capital investment over the next 10 years and will represent £3.2 to 6.4 billion of operations and maintenance contracts across the 40 year lifetime of the infrastructure (DECC, 2015f). The HNIP aims to provide some of this required capital investment in order to unlock sufficient equity investment to establish a self-sustaining industry.

Notwithstanding the development of the HNDU and the HNIP, heat networks operate in a relatively weak institutional environment in the UK as they are unregulated, with the exception of metering and billing regulations introduced as a result of the EU Energy Efficiency Directive. A number of industry led initiatives have been developed in the last five years including the Heat Trust consumer protection scheme, the CIBSE/ADE technical code of practice and the development of a District Energy Procurement Agency.

Additionally Heat Network (Metering and Billing) Regulations 2014 came into force in December 2014 which implement the requirements of the EU Energy Efficiency Directive in relation to the supply of distributed heat, cooling, and hot water. The regulations aim to increase the accuracy of heat metering and billing in order to protect consumers and support further development of the market.

The Heat Trust independent voluntary consumer protection scheme

The Heat Trust was launched in November 2015 and enables consumers to access an independent process for settling disputes via the Energy Ombudsman and ensures minimum consumer standards (Heat Trust, 2015). To become a Heat Trust 'member', a supplier must agree to the terms of the

[12] At the time this was based on 122 projects supported by the HNDU in 91 local authorities.
[13] Such as schemes led by housing associations and private developers.

scheme and pay a joining fee, as well as a fee per connection. Members also sign up to protecting customers through not disconnecting vulnerable customers during the winter and guaranteeing service payments to customers when the supplier fails to meet performance standards (Which?, 2015). BEIS provided start-up funding for the Heat Trust which was developed by the Association for Decentralised Energy (ADE).

Technical Code of Practice

Recognising the need to develop consistent technical standards the Chartered Institution of Building Services Engineers (CIBSE) and the ADE developed a technical code of practice for heat networks which was launched in July 2015. The code sets out minimum technical standards to ensure the quality and efficiency of networks, covering initial design, construction, commissioning, operation and maintenance (CIBSE and ADE, 2015). BEIS supported the development of the code.

District Energy Procurement Agency (DEPA)

The District Energy Procurement Agency (DEPA) is a municipal not-for-profit procurement cooperative specialising in goods and services in the district energy market. It is modelled on, and is being developed in collaboration with, VÄRMEK a similar existing organisation in Sweden. DEPA aims to reduce heat networks project costs in the UK through joint procurement and is being developed by Manchester City Council with a grant from BEIS (Greater Manchester Combined Authority, 2017). UK heat network project costs are estimated to be 20% higher than the European average, largely due to the small size of the industry in the UK, limited supply chains and a lack of large scale procurement (Poyry Energy and Faber Maunsell, 2009).

This section has outlined the policy framework for heat networks in England. Much of this policy activity has focussed on the techno-economic dimensions of developing heat networks, such as difficulties in financing heat networks, the need for common standards and the lack of sector skills, however, the development of heat networks also involves complex actor networks and interrelates with existing policy, institutional and social factors. The next section therefore examines these factors through discussing the role of local authorities in heat network development. The final section in this chapter also discussed the various barriers to further heat networks in both country contexts.

2.5 The role of local authorities and cities

Local authorities are widely acknowledged as playing a unique role in coordinating and developing heat networks due to the long-term perspective they are able to take in relation to investment, their role in incorporating social and environmental objectives, their ability to coordinate multiple local (and beyond) actors, their capacity as planners and operators of significant heat loads and their ability to lever in low cost finance and grant funding (Hawkey and Webb, 2012; UNEP, 2015). Despite this, there is a wide variety of roles local government can take in relation to heat networks, with potentially significant implications for financing, objectives and delivery. In addition there have been significant changes to the role, powers and financing of local government over recent years. The following section outlines these developments and reviews the (changing) role for local governance in the England, together with consideration of the role of local authorities in the energy system and heat networks specifically.

2.5.1 Changes to local government role and powers

The UK is well established as an example of a particularly centralised state, based on Parliamentary sovereignty, a government centred on London and subordinate regional and local government (Wilson and Game, 2002; Bulkeley and Kern, 2006). However the development of more dispersed and complex forms of governance in recent decades have seen changes not only in the distribution of competencies and powers between local, regional, national and supranational public institutions but also increased involvement by non-state actors and public-private partnerships (Hooghe and Marks, 2003; Bache and Flinders, 2004). Since 1997 this has included a process of devolution for Scotland, Northern Ireland and Wales which led to the establishment of a national Parliament in Scotland, a national Assembly in Wales and a national Assembly in Northern Ireland.

Additionally there has been a long-term trend since the 1980's towards a more enabling state with a move away from hierarchical, direct service provision to a focus on the outsourcing and privatisation of services and more complex partnership based governance structures (Giddens, 2003; Bache and Flinders, 2004; Rhodes, 2007; Le Gales and Scott, 2010). In this context the state's role is to enable outcomes rather than to directly provide services and a similar shift towards an 'enabling' role for local authorities has been well documented (Bulkeley and Kern, 2006; Monstadt, 2007; Schönberger, 2013). This has been realised through the increasingly managerial approach of local public administration, the move to local governance structures that delegate tasks to the private sector, and a focus on more networked modes of governance (Bohne, 2011).

In England, devolved Parliaments or regional governments do not exist outside of London, although there have been various experiments with sub-national governance and delivery structures, including Regional Assemblies[14], Regional Development Agencies, Government Offices for the English Regions, Local Enterprise Partnerships (LEPs) and directly elected city (or city region) Mayors (Garnett and Lynch, 2009). Despite these experiments local governance in the UK has historically been dominated by limited devolution of funding and powers, a limited relationship between local and central government and the supremacy of the 'ultra vires' principle which permits local government to only undertake statutory functions (Wilson and Game, 2002). More recently successive governments have pursued a 'localism agenda' including the development of a General Power of Wellbeing in the 2000 Local Government Act which amended the *ultra vires* principle and allowed local authorities to undertake any activities which contributed to the wellbeing of their residents. However this power was not widely used and there were uncertainties regarding the ability it conferred on local authorities to establish commercial undertakings (Department of Communities and Local Government, 2008; Mountfield, 2012). Recognising this the Localism Act 2011 aimed to further devolve power to local areas and replaced the Wellbeing Power with a General Power of Competence which

[14] Regional Assemblies existed in the 9 English regions between 1998 and 2010. The London Assembly was established via separate legislation and continues to exist.

enables English local authorities[15] to undertake 'anything that an individual can do' (HM Government, 2011, p. 4; Sandford, 2014, p. 1), specifically empowering them to do anything not prohibited by legislation or outside of public law.

While the scope of the General Power of Competence and the extent to which the Localism Act actually devolved power are both disputed[16] (Jones and Stewart, 2012; Mountfield, 2012) they do represent an overarching commitment to new forms of local interaction, investment and partnerships. Most recently processes of local government devolution in England have included the development of 'devolution deals' which establish an agreement between local areas and central government regarding the passing of some power to local areas. To date, ten devolution deals have been agreed and a number of others are under development[17] (Local Government Association, 2018; Sandford, 2016). This is supported by the Cities and Local Government Devolution Act 2016 which allows for the devolution of powers from the UK government to some of England's towns, cities and counties through the introduction of directly-elected mayors to combined authorities and the devolution of housing, transport, planning and policing powers. It also sets the framework for further devolution deals to be agreed with government.

Notwithstanding these processes of devolution English local authorities still have relatively limited autonomy, particularly in comparison with other countries in the European Union, and only restricted funding and powers have been devolved to date (Centre for Cities, 2016; Wilson, Crews and Mirza, 2017). A range of measures, such as the proportion of revenue raised by sub-national government compared to the G8 or the rest of Europe, the proportion of total government spending undertaken by sub-national government, and the number of statutory obligations that local government is required by Parliament to fulfil, all suggest that governance in England remains significantly centralised (Booth, 2015).

[15] The power does not extend to Wales, Scotland or Northern Ireland.
[16] For example the general power of competence does not permit local authorities to raise new taxes.
[17] An additional three were initially agreed but subsequently collapsed.

In respect of energy, local authorities have a very limited statutory role with energy policy and regulation delivered nationally and the local governance of energy infrastructure restricted to planning powers for projects up to 50MW, with projects over this scale dealt with by central government (Barton *et al.*, 2015; Cowell, Ellis and Strachan, 2017). However, while specific local powers relating to energy are limited local authorities have a long history of action on climate change, including over 300 local authorities signing the Nottingham Declaration on Climate Change in 2000 which committed signatories to undertaking local action to reduce greenhouse gas emissions and preparing their communities for the impacts of climate change (Friends of the Earth, 2011; Castán Broto and Bulkeley, 2013; Fudge, Peters and Woodman, 2016).

Government policy has recognised a significant role for local government in emission reduction with climate and energy policy documents consistently highlighting an important local role. However this has tended to focus on the potential for carbon reductions from the public sector estate or the role of local government in land-use and transport planning (HM Government, 2007; DECC, 2009b, 2011). In the past the expectation from national government that local governments will act on emission reduction was formalised through the inclusion of a number of climate change targets in national performance targets for local government. These targets were removed in 2010 and policy documents since this date have tended to highlight an important but unspecific role for local authorities in decarbonisation (DECC, 2011; Fudge, Peters and Wade, 2012). This lack of a mandate from central government for local action on climate change may have contributed to a great deal of variation in local government response to climate change, with recent research suggesting that there is wide variation in the engagement of local authorities in the energy system (Tingey, Webb and Hawkey, 2017).

In summary, in recent decades, local governments in the UK have largely taken a peripheral role in the direct ownership of energy infrastructure and there has been little discussion to date regarding whether the energy transition will prompt or require sub-national governments to take new and/or different roles in the energy system. The next two sections therefore summarise the historic and changing role of local authorities in the energy system in England together with the roles commonly played by local authorities in heat networks.

2.5.2 The historic and changing role of local government in energy

Local government historically played a much more significant role in the energy system in England. Many of the first public supplies of (town) gas were municipally owned (DTI, 2004) and local authorities were closely involved in the establishment of networked energy infrastructures in the nineteenth and early twentieth Centuries. During this time it was common for municipal enterprises to develop and operate local electricity, (town) gas and water boards and, up to the 1940's, well over 300 publically owned electricity suppliers were in operation in the UK (Hannon and Bolton, 2015). Following World War II municipally- and privately-owned energy generation and supply undertakings were nationalised in the UK, driven by a focus on the economies of scale of operating networks on a national basis, the need to standardise operations to enable rapid economic growth, and the desire to provide universal access to energy services (Kuzemko, 2013a). These energy system nationalisations largely removed local government involvement in energy infrastructure and led to the development of a system based on national grids and centralised generation of power (Wollmann, 2004; Hawkey and Webb, 2012). This peripheral role for the sub-national state was then further embedded as liberalisation progressed in the 1990s and early 2000s.

Although local authorities have largely played a marginal role in the English energy system in recent decades there are also some indications that councils in the UK are increasingly interested in taking an active role in the energy system (Hetherington, 2013). As discussed local authorities are almost invariably important actors in heat network projects, over 130 local authorities are progressing heat network projects via the HNDU and an increasing number of local authorities are exploring the potential to develop energy supply companies which may include heat networks, this includes Nottingham, Bristol, Liverpool, Leeds, Manchester and London exploring municipal energy supply options[18].

This resurgence of interest in local authority involvement in the energy system is driven by a range of factors. Firstly, a dramatic reduction in the local government funding settlement is driving some to consider alternative routes to raising revenue (Lowndes and Mccaughie, 2013; Travers, 2013). Secondly, the devolution agenda discussed above has introduced or amended a number of powers to allow local authorities to undertake activities outside of their statutory responsibilities and be more commercial (Sandford, 2014; Communities and Local Government, 2009). These new powers, together with a 2010 removal of the ban on local authorities selling electricity they generate, make it easier for local authorities to engage directly in energy generation and supply activities.

2.5.3 Heat networks and local authorities

The current liberalised structure of the UK energy system means that a heat network could, in principle, be delivered by any organisation (Hawkey, 2009). However, although the previous section has outlined that local authorities have played a limited role in the energy system in England for many decades, they have tended to play an important role in the development of heat networks. This has been for a number of reason. Firstly heat networks are inherently local, with costs and heat losses necessitating a localised scale of heat generation and distribution. Secondly, the need to concurrently develop heat generation, distribution and a range of heat customers requires actors to work together to develop a system, this often includes the local authority playing a brokerage and coordination role. Thirdly, local authorities are able to commit to the long-term strategic planning required to develop heat network projects and are likely to own and/or operate significant heat loads. Finally, local authority drivers to address multiple social, economic and environmental objectives may mean they are well placed to act as the coordinating organisation for heat network projects. BEIS summarises this as local authorities playing an ‘important role’ in setting the strategic context for and initiating the development of new district heating

[18] To date Nottingham and Bristol have established municipal supply undertakings and Leeds and Liverpool have developed a municipal White Label arrangement in partnership with Nottingham’s Robin Hood Energy.

networks (DECC, 2012, p. 72) with their ‘local knowledge, capacity for organisation, and key functions as planning authorities and service providers’ putting them in a unique position to drive new schemes (BRE et al., 2013).

Despite these key roles engaging in heat network projects has not been straight forward for many local authorities. This is partly due to historic local authority accounting procedures, which aimed to prevent cross-subsidy between local authority activities but effectively required that heat network schemes were appraised on commercial terms rather than against social objectives (Russell, 2010). In contrast, European district heat systems have often been cross subsidised by other local government investments, justified by reference to social objectives such as energy savings, affordable heating, regeneration and employment opportunities (Hawkey, 2013). However, local authorities can play a wide range of role(s) relating to heat network schemes and experience to date in the UK has been characterised by significant local experimentation with each area developing their own contractual and organisational forms. Similarly other local actors can plan important roles including Housing Associations, the NHS, Universities, Housing Developers and commercial heat network developers (Heat and the City Project, 2011).

2.6 Heat networks in Germany

The previous sections outlined the development of heat networks in England, together with the historic and changing role of local authorities. This section outlines the current status of heat networks in Germany and the role of municipalities. It begins by summarising the structure and governance of the German energy system, the status of heat networks and policy support. Emerging processes of energy infrastructure remunicipalisation are then reviewed and a number of conclusions made regarding the significance of these developments. The chapter ends by discussing barriers to heat network growth in England and Germany.

2.6.1 The German Energy System

The German energy sector is currently in a major transition towards a low carbon system and, in 2010, the Federal Government adopted the 'Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply' defining the future German energy system until the year 2050 (BMU and BMWI, 2010). The Energy Concept built on the 2007 Integrated Energy and Climate Programme but adopted more ambitious goals, committing Germany to reducing greenhouse gas emissions by 80% to 95% by 2050, and to producing 80% of the country's electricity from renewable sources by the same date (Richter, 2013)[19].

Initially the Energy Concept included a proposal to extend the operating life of the German nuclear power fleet by 12 years (postponing the nuclear phase out agreed by the previous government). However, following the 2011 Fukushima Daiichi nuclear accident a decision was made, with widespread public support, to accelerate the phase-out of Germany's nuclear fleet to 2022 with the immediate closure of the eight oldest plants. This had a major impact on Germany energy policy resulting in a second document announcing the transformation of the energy system (known as the

[19] The GHG reduction targets are to reduce emissions by 40% by 2020, 55% by 2030, 70% by 2040 and 80% to 95% by 2050, each relative to 1990.

'Energiewende') which aims to speed up the energy concept to compensate for the nuclear phase out (Schmidt, Jäger, & Karl, 2012; International Energy Agency, 2013).

Heating and cooling accounts for 56% of final energy demand in Germany, of which approximately 55% is used for space heating, 32% for process heat, 9% for domestic hot water and the remaining 4% split across process cooling and other sources of heat (Heat Roadmap Europe 2050, 2017a). There is increasing focus on the need to decarbonise heat in the Energiewende, partly driven by evidence that the German residential heating sector is not on track to meet decarbonisation targets. Delta-EE research suggests that Germany will miss their 2025 residential emissions reduction targets by approximately 20% based on current trends in policy, techno-economics, energy efficiency and customer behaviour (Hardy, 2015). Heat networks are likely to play an important role in decarbonisation and the German government has put a strong emphasis on expanding both heat networks and CHP, including setting a target to increase the market share of electricity from cogeneration to 25%. There is also widespread recognition that, as the Energiewende progresses, CHP and heat networks are likely to become increasingly important as a source of 'controllable power' to complement intermittent renewables and provide opportunities for heat storage (Agora Energiewende, 2013: 10).

2.6.1.1 Energiewende governance

In total six federal ministries have relevant jurisdictions concerning the Energiewende, although the Federal Ministry of Economic Affairs and Energy (BMWi) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) are the most significant actors.

The BMWi is responsible for the energy market, supply (with the Federal Cartel Office/ *Bundeskartellamt*), energy efficiency and the grid (with the Federal Network Office/*Bundesnetzagentur*). They also have a range of subordinate offices such as Federal Office of Economics and Export Control (Bafa) and the German Energy Agency (DENA)[20]. The BMU is responsible for renewable

[20] DENA is a public-private partnership.

energies (apart from bioenergy), environmental protection, and nuclear safety. Under the BMU the Federal Environmental Agency (UBA) is responsible for the EUETS in Germany. The German Renewable Energy Agency is also affiliated to the BMU with some overlap in responsibilities with DENA (Kemfert and Horne, 2013).

The BMWi is responsible for a range of policies to support heat networks and CHP (as described in section 2.6.1) and the Federal Office of Economics and Export Control (Bafa) has responsibility for implementing the CHP law. The Federal Network office regulates the gas and electricity grids, but does not regulate heat networks which are overseen by the Federal Cartel Office. The governance of the Energiewende is also complicated by the federal governance structure in Germany where the sixteen Länder, and beneath that numerous municipalities, have significant autonomy particularly in relation to land use planning and heat. For example, in 2008 the state of Baden-Württemberg was the first to establish a Renewable Heat Law making the installation of a percentage of renewable energy for heating compulsory in any renovation of existing residential buildings (Jörgensen, 2012).

2.6.1.2 History of energy system development

There is a long history of diverse ownership in the German energy system. Unlike in the UK a national energy generation and supply monopoly was never established in Germany and prior to liberalisation in 1998 a mix of (often vertically integrated) public and privately-owned suppliers operated under a regime of regional supply monopolies which were not subject to competition (Danwitz, 2006). From the 1980's Germany pursued a programme of liberalisations, however the process in Germany was rather more 'creeping' than the rapid process in the UK and Germany only progressed liberalisation and unbundling when directed to do so by the EU[21] (Heddenhausen 2007: 15). Initially, this involved the Federal state selling its stakes in the energy companies VEBA AG and VIAG AG in the 1980's. However, these privatisations were restricted to the Federal level and the regions (Länder) kept their investments, as did municipalities. This was partly due to the structuring of

[21] Specifically 96/92/EC.

federalism in Germany where natural resource and water rights had historically been held by states and had been used to develop Land electricity companies, and partly due to ongoing political support for a coexistence of private, mixed-economy, and public companies (Heddenhausen, 2007).

It was not until 1998, when the EU Electricity Directive was transposed into national law, that regional monopolies were banned and electricity suppliers were forced to separate generation, transmission and distribution (Moss, Becker and Naumann, 2014). At this time a small but significant number of municipal energy companies remained in operation, partly supported by an exemption from unbundling rules which enabled them to continue to operate generation, distribution and supply[22]. However, liberalisation led to a high number of acquisitions and mergers and the gradual dominance of the German ‘Big 4’ (E.ON, RWE, EnBW and Vattenfall) who, by the mid-2000s, generated over 90% of electricity and controlled over 70% of the retail market. At this stage the Big 4 also owned the transmission grids (but have since been forced to unbundle by the EU) and distribution networks were run partly by local public utilities and partly by the Big 4, sometimes through jointly-owned companies (Hall, Lobina, & Terhorst, 2013a). During this period the number of publicly owned (municipal) utilities reduced as many cities faced funding shortfalls and sold undertakings to raise money, often to the ‘Big 4’. The Big 4 also increasingly held minority shares in local public utilities (Heddenhausen, 2007).

Today, in the context of increasing penetration of renewable generation[23], ownership of energy provision in Germany is ‘highly diverse, involving the complex interplay of actors operating on multiple scales’ (Moss *et al.*, 2014: 9). This includes over 1000 electricity supply companies, with the average householder choosing from 72 suppliers. Although they still own the majority of generation infrastructure, the ‘Big 4’ control less than 50% of the domestic retail market and there are almost 900 distribution grid operators – 812 of which have fewer than 100,000 customers (Julian, 2014). Individual and co-operative

[22] 2005 EC Acceleration Directive 2003/54 was transposed to German law (through amendment to the Federal Energy Act) with an exemption for energy companies with less than 100,000 consumer households.
[23] In 2016 renewable sources accounted for 31.2% of electricity consumption (Bundesnetzagentur and Bundeskertellamt, 2017).

ownership of renewable energy infrastructure has also developed rapidly in Germany and from 2004 to 2014 over 800 energy co-ops were founded in Germany (Yildiz *et al.*, 2014).

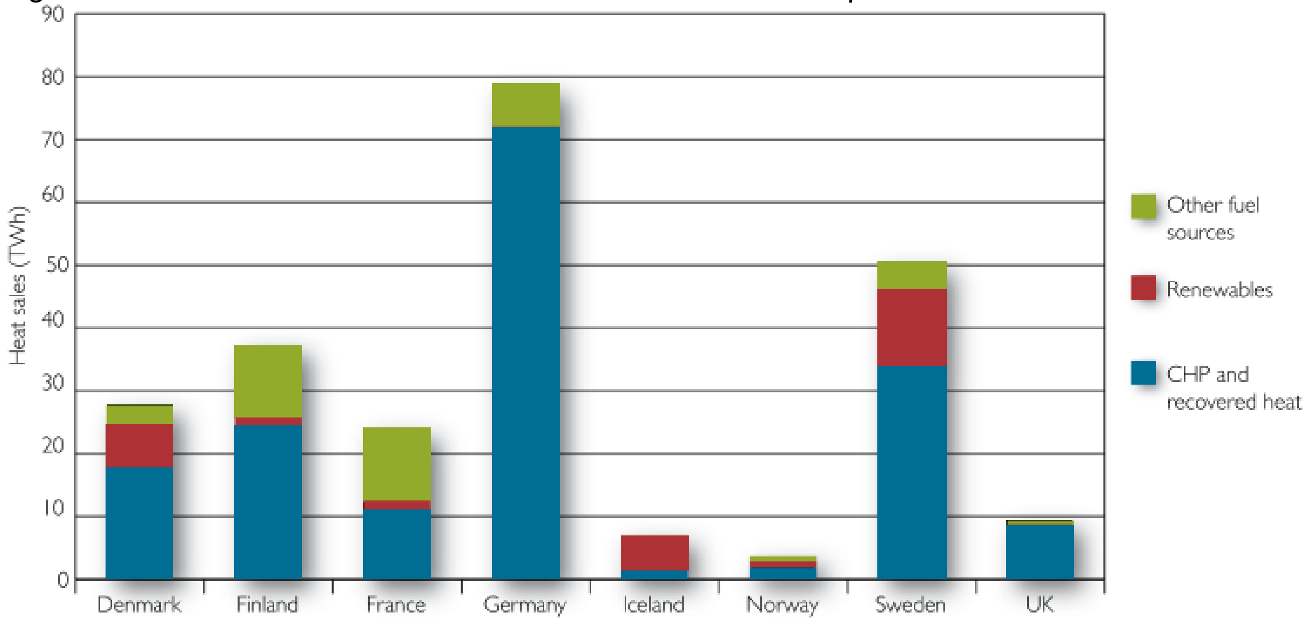
These changes to ownership structures in the German energy system are relevant to the development of heat networks as the majority of heat networks are (at least partly) owned by municipalities so development has therefore been closely linked to the changing role of municipal energy companies. These issues are discussed further in section 2.6.3. The following sections first outline the current extent of heat networks in Germany and policy support measures.

2.6.2 Heat policy in Germany

2.6.2.1 Heat networks in Germany

In Germany approximately 12% of heat demand is met through heat networks, however, due to its population size, Germany has the second largest[24] total installed heat network capacity at 49,691MWth and the largest heat market, as illustrated in figure 9 (Energy Technologies Institute, 2012; Euroheat and Power, 2013; Committee on Climate Change, 2014).

Figure 9: Heat sales to customers via heat networks in Europe



(DECC, 2013b)

[24] After Poland.

Similar to the UK, the development of heat networks in Germany started in the late 19th Century with the first modern scheme (based on CHP) established in Hamburg in 1893. Several networks were developed in the early 1900s, often with city utilities playing an important role, but further development was set back by World War II. The growth of heat networks recovered in West Germany shortly after the war and was boosted in the 1970's by the global oil crises (Lutsch and Orita, 2009). Following the reunification of East and West Germany there was investment and refurbishment of many existing heat networks in the eastern part of Germany.

As discussed, and in contrast to the UK, France and Italy, Germany did not experience a period of post-war nationalisation of the energy sector. A range of municipally owned utilities were therefore still in place at the time of energy market liberalisation, often owning heat network infrastructure and supply. Liberalisation of the German electricity market had a significant effect on the development of CHP-heat networks as it resulted in a substantial decline in electricity prices. This particularly effected CHP as although the combined efficiency of electricity and heat production is far higher than conventional generation the cost of generating electricity is higher than large-scale electricity only power plants so the economics of CHP was less attractive than large-scale power generation.

Currently approximately 12% of heat demand is met by heat networks in Germany; 46% of heat network customers are private homes, 36% public buildings, commercial and trade sector, and 18% industry (Huther, 2010; Euroheat and Power, 2015). In recent years, in the context of the Energiewende, the German government has put a strong emphasis on heat networks and CHP and analysis suggests that approximately 56% of residential and administrative buildings are suitable for district heating supply (Lutsch, 2014). Currently approximately 40% of heat networks in Germany are fuelled by coal (Hamburg Institut Research GmbH, 2015), however the use of fossil fuels in heat networks is forecast to decrease significantly by 2050 in government scenarios. Across the reference, energy efficiency and renewable energy scenarios considered by the BMWi, heat network emissions decrease by between 30-38% by 2020 (compared to 2008) and between 60-75% by 2050 (BMWi, 2015a). This will involve significant changes to existing heat network generating technologies including switching to gas-CHP and renewably fuelled networks. The Federal Government has recognised the need for existing grids to transition to low carbon supply with the Energy Efficiency Strategy for Buildings highlighting the importance of developing low temperature heat grids in order to utilise geothermal and other renewable sources of heat, as well as stored heat[25] (BMWi, 2015a).

The four major German utilities all have commercial interests in CHP and heat networks, however the involvement of Eon and Vattenfall has mainly been though connecting conventional power plant to heat networks and RWE and EnBW have focussed on industrial applications. In contrast a high number of municipalities (stadtwerke) have developed CHP and heat network infrastructure.

2.6.2.2 German heat network policies

In addition to the policy commitments set out in the Energy Concept, a number of legislative measures and programmes have been adopted to support the growth of heat networks and CHP as outlined in this section. These measures have been widely welcomed by the sector as progressive (Huther, 2010) and in their assessment of CHP and heat network policy in 2008 the International Energy Agency (IEA, 2010; IEA, 2009: 11) scored Germany 4 out of 5 stars (the UK scored 2.5 stars). The rating system aims to reflect:

- The effectiveness of policies in developing the CHP and heat network market;
- Statements and commitments of intent in respect of future CHP and heat network policy, for example through the creation of national growth targets; and
- The existence of meaningful policy incentives that are causing significant market growth or that are likely to do so in the near future.

[25] Such systems are referred to as 4th generation district heating.

The IEA have not repeated the assessment since 2008. However German policies have been extended or improved rather than scaled back since 2008 (see 2.6.2.2) so it is likely that German CHP/heat network policy has retained or improved its 4-star rating. Although the heat network sector largely welcomes the support for CHP and heat networks there is some criticism that provisions are not sufficient to promote the transformation to renewable energies in heat network supply (Hamburg Institut Research GmbH, 2015).

To date supportive policy for heat networks has been underpinned by the 2009 Renewable Heat Act and the Combined Heat and Power Act. The Renewable Heat Act aims to increase the share of renewable heat to 14% by 2020 and sets a requirement on new building owners to source a proportion of their heat from renewable energy systems or heat networks[26]. The German CHP Act (KWKG) has provided financial incentives for CHP since 2001 and has undergone several amendments. The early law supported existing CHP plants through paying a bonus for electricity exported to the grid. This was extended in 2002 to include new cogeneration installations up to 2MWe and modernisation investments in cogeneration plants with higher capacity (Golbach, 2012).

In 2009 an updated CHP Law introduced the aim of 25% of electricity production from CHP but did not stipulate a timescale. At this stage support for heat networks was also specifically introduced, providing up to 20% of investment costs[27]. The total budget for the KWK was set at a maximum of €750 million per year, including a maximum of €150 million for new or expanding heat networks. The support is funded by consumers through a levy on the grid operators and if the €750 million limit is exceeded then installations over 10 MWe get proportionally less (Golbach, 2012).

In 2012 the KWKG was again amended to improve the incentives for investments in cogeneration plants and introduce a target of 25% of electricity from CHP by 2020. This target relates to cogenerated electricity only and there

[26] The minimum percentage depends on the renewable energy technology used.
[27] Grants of up to 20% of investment costs were available if a network is supplied with at least 60% of heat from cogeneration and is in operation by 31 December 2020, up to a maximum of €5 million per project.

are no targets relating to the share of cogeneration in the heating market, however the electricity target implies a corresponding increase in heat networks to approximately 18%–22% of the heat market in 2020 (CODE2 Cogeneration Observatory and Dissemination Europe, 2013; BMWi, 2015b).

In 2016, during the period over which this research was conducted, new amendments were introduced to the CHP law. This involved increases to the gas-fired CHP surcharge, the removal of coal-fired CHP plants from eligibility and a change in the CHP target. The 25% CHP target has effectively been reduced with the definition changed from CHP providing 25% of electricity by 2020 to CHP providing 25% of non-renewable electricity by 2020. Support is now also available for district cooling grids and thermal storage used in conjunction with CHP plants (CODE2 Cogeneration Observatory and Dissemination Europe, 2013; BMWi, 2015b). The overall cap for support remains at €750 million per year (€150 million for heat networks and storage). This is relatively inexpensive compared, for instance, to the support for renewable electricity which costs approximately 40 times more. For the average householder CHP support measures are likely to increase energy bills by €4.6 per annum (Orita, 2013).

Additional support for heat networks is also available directly to municipalities through a range of Federal Government programmes. This includes the 'Energy Efficient Cities' (EnEff:Stadt) and 'Energy Efficient District Heating and Cooling Supply' (EnEff:Wärme) programmes which support planning, research and pilot projects at an urban level, including heat networks (BMWi, 2014). The German government owned development bank, KfW, also supports municipalities through the 'Energetische Stadtquartiere' (Energetic Neighbourhoods) programme. The scheme provides low cost loans to municipalities to plan, organize, and implement district-wide retrofit schemes and to implement heat networks (Morris and Pehnt, 2012; Bröer, 2013).

2.6.2.3 Heat network regulation in Germany

Heat networks in Germany are governed by the 'Ordinance on general conditions for the supply of district heating' (AV BFernwärmeV), which sets standard business conditions for the supply of heat network customers and requires network operators to meet certain technical and customer service standards (Orita, 2013)

Heat network pricing is regulated by the Federal Cartel Office (Bundeskartellamt) who monitor the industry and carry out random checks on heat network operators to analyses prices. These enquiries are carried out on an ex-post basis and only undertaken when concerns are raised by consumer or other interested groups. Those identified as charging unnecessarily high prices, in comparison with other networks, are subject to legal proceedings and/or fines. In addition, in 2012, due to concerns regarding the intrinsic monopolistic[28] structure of heat networks, the Federal Cartel Office carried out a sector inquiry to establish the impact of heat network monopoly supply on competitive behaviour and market outcomes.

The inquiry examined the profits of thirty companies including many municipal utilities and the four most important privately owned utilities E.ON AG, RWE AG, EnBW Energie Baden-Wuerttemberg AG and Vattenfall Europe AG. Based on price data from 2007 and 2008 the Cartel Office found sufficient reason to suspect some prices were inflated, with some companies charging prices over the average. The inquiry investigated heat network operator revenue and did not find heat network prices, overall, to be excessive when compared to other heating technologies. They did, however, find great variation between networks with larger networks (>100km network length) considerably cheaper (average revenue of 7.0cent/kWh) than small (1-10km, 10.1cent/kWh) and medium (10-100km, 8.9 cent/kWh) networks (Bundeskartellamt, 2012).

Following the inquiry the Bundeskartellamt determined to continue to monitor district heat revenues but did not consider it advisable to unbundle and regulate district heating networks due to the closed system nature of heat networks and associated difficulties in transporting heat between systems. Additionally,

[28] The inquiry highlighted that once a customer connects to a heat network they are, in effect, limited to one monopoly supplier. In addition in some areas connection to and the use of the municipal district heating system may be compulsory, providing the district heating supplier with legally protected monopoly position.

customer surveys have suggested that heat networks have the highest overall customer satisfaction when compared to gas, oil and other forms of heating (Euroheat and Power, 2013).

The German Cartel Office again investigated heat network prices in 2013. Following the 2012 investigation this specifically focussed on seven utilities in 30 supply areas where there were concerns regarding prices. The review investigated the prices charged by the companies between 2010 and 2012 and compared them to eight competitors with comparatively low revenue and prices. The review was complex, accounting for the impact of the vertically integrated nature of heat networks and the impact of varying generation and grid structures on prices, but led to Stadtwerke Leipzig GmbH agreeing with the Bundeskartellamt to lower its district heating prices by €8million per year over a period of five years (Bundeskartellamt, 2015).

2.6.3 German governance and stadtwerke

The principle of local self-government is embedded in the constitution of Germany (the *Grundgesetz* or Basic Law) with Article 28 suggesting that local authorities 'regulate all local affairs on their own responsibility' through their own service provision entities (Schönberger, 2013, p. 10). However Libbe (2008) suggests that significant changes to the structures and functions of German local authorities over recent decades have resulted in more complex local governance arrangements. This includes the outsourcing of services and the use of public-private partnerships with services delivered directly by municipalities, by semi-autonomous municipal agencies and by a wide range of privatised organisational forms.

These developments have been particularly relevant for German municipalities due to ongoing financial crises caused by significant reductions in municipal revenue due to reforms by the red–green government in the early 2000s. Bulkeley and Kern (2006) suggest this eroded the principle of self-government as most local governments were constrained to only deliver statutory services. In this context Bulkeley and Kern's (2006, p. 2241) analysis of local climate change governance in Germany and the UK identifies four modes of governing;

(1) self-governing, the capacity of local government to govern its own activities; (2) governing by provision, the shaping of practice through the delivery of particular forms of service and resource; (3) governing by authority, the use of traditional forms of authority such as regulation and direction; and (4) governing through enabling which relies more on partnerships and delegation. They suggest that there is a gradual move towards governing through enabling in Germany[29] and align this with a dominant trend, since the 1980s, of privatisation and outsourcing of public services (See for example Hood, 1995; Bache & Flinders, 2004; Le Gales & Scott, 2010). In relation to energy this included public monopolies being perceived as inefficient, unresponsive to consumer demands and low innovators, as liberalisation progressed in the 1990s and early 2000s (Monstadt, 2007). At the same time privatisation was seen as a route to achieving better customer outcomes and many municipal utilities were part or fully privatised. At this point a number of authors (such as Bulkeley & Kern, 2006; Monstadt, 2007) suggested that the importance of municipalities in the energy sector waned and would continue to do so in the future.

2.6.3.1 A changing role for municipalities?

Up until liberalisation the German energy system incorporated a wide mix of public and private entities. This commonly included municipalities owning local public utilities (or stadtwerke). These 'local public utilities' are represented by the German Association of Local Utilities (VKU) who define their members as companies that 'provide services of general interest in Germany within the framework of local self-government' (VKU, 2013). Stadtwerke do not primarily pursue private commercial objectives but are guided by public welfare obligations. There are close to 1500 stadtwerke in Germany[30] (Julian, 2014) and the VKU suggests that this number is increasing rapidly (Witte, 2012).

Municipalities can establish energy companies on the basis of the regional (Länder) Municipal Codes. These codes vary significantly regarding the limits of municipal economic activities however a significant number allow municipalities to undertake profit-making activities if they serve a public goal and the service

[29] And the UK, as discussed.
[30] Although not all are active in energy or district heat.

can be fulfilled as effectively as by a private company. Other Municipal Codes are more restrictive and demand that the public service can be fulfilled more efficiently than by private companies (Schönberger, 2013).

In addition to their ability to establish stadtwerke, municipalities (and Länder) have considerable powers over spatial planning in Germany and can introduce measures to require new building owners to use CHP for heating or to connect to an existing district heating system (Eurelectric, 2014). All regional (Länder) Municipal Codes include this option (Schönberger, 2013). Municipalities can also identify priority areas for renewables and heat networks in their Preparatory land-use plans, although these plans must be compatible with the regional plan.

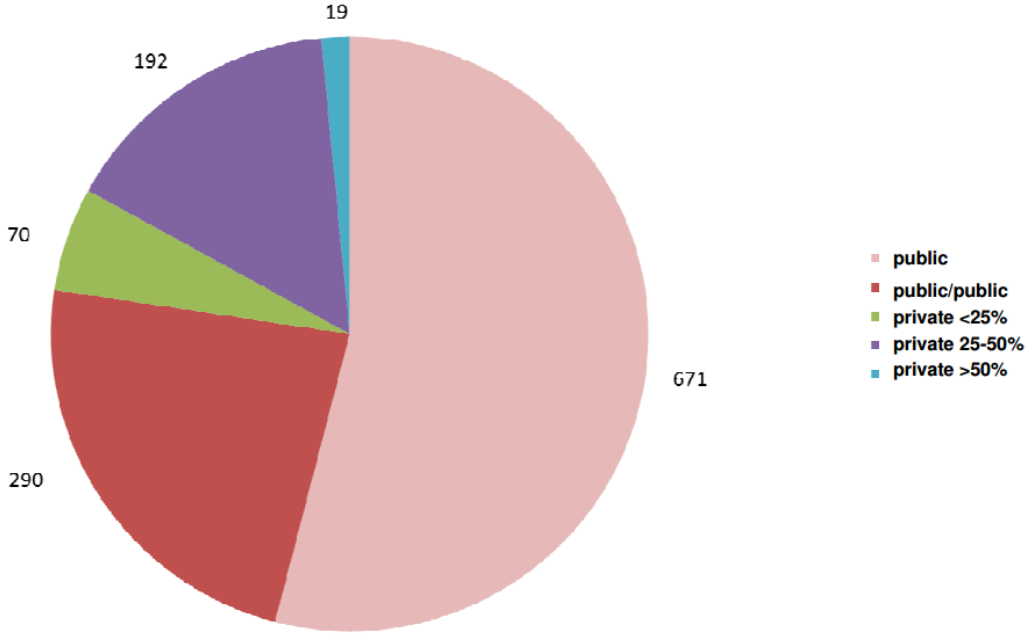
Despite this diversity the liberalisation of the German electricity market in the late 1990's saw a reduction in municipal ownership of energy infrastructure as a high number of mergers and acquisitions resulted in the emergence of the German 'Big Four'[31] (Jansen, 2011). Under competition from the Big Four, and increasing budgetary pressures, many stadtwerke sold local grids, heat networks and generation capacity to the large national suppliers. The number and scope of stadtwerke decreased and large municipalities such as Hamburg and Stuttgart sold their energy companies to Vattenfall and EnBW respectively in the early 2000's (Wollmann, 2012). Those stadtwerke that remained tended to restrict themselves to distribution while generation and supply was dealt with by big private companies. During the 1990s, the municipal services came under increasing financial pressure as budget constraints limited investment and stadtwerke were expected to produce higher returns (Bulkeley and Kern, 2006). Becker et al. (2017) also suggest that a dominant view of public ownership as unaccountable and prone to corruption also legitimised the privatisation of stadtwerke.

Whilst all public utilities are partly publicly owned they operate under a variety of structures, ranging from full public ownership to less than 50% publically owned as illustrated in figure 10. Similarly whilst some stadtwerke are actively progressing the transition to renewable energy in Germany others remain

[31] E.ON, RWE, EnBW and Vattenfall

conservative with limited integration with national decarbonisation policy (Barton *et al.*, 2015).

Figure 10: Stakeholder structure of Local Public Utilities in Germany



(Witte, 2012)

Whilst stadtwerke operate a range of energy generation facilities, they are particularly active in low carbon generation systems such as CHP-heat networks and renewables (which represent over 90% of their generation capacity) (VKU, 2013) due to the alignment between these schemes and wider municipal carbon reduction targets. These local public utilities are increasingly being seen as central to the Energiewende and Deutsche Bank (Auer & Heymann, 2012: 1) suggests that the low carbon transition will 'pave the way for municipalities and municipal utilities to enter new spheres of activity in terms of energy provision'.

Although there was a significant overall decrease in municipal utilities in Germany following liberalisation there is increasing evidence that Germany is now seeing a resurgence in the importance of municipal utilities with the number and size of stadtwerke increasing and several taking a role in the ownership and development of heat networks. The number of German municipal companies increased by 22% between 2000 and 2010 and over 70 public stadtwerke, incorporating some element of energy provision, have been established since 2007 (Becker, Beveridge and Naumann, 2015).

Additionally several consortia of stadtwerke have acquired previously privately owned assets and supply companies. This includes Thüga, a former subsidiary of E.ON, being bought by a consortium of 100 stadtwerke for €3 billion in 2009 (Wollmann, 2012). Similarly Stuttgart sold its municipal energy company to EnBW in 2003 but repurchased the assets and founded a new stadtwerke in 2014 to integrate water and energy provision. The government of Baden-Wuerttemberg also bought back 45% of EnBW for €4.7 billion Euros from the French multinational EDF in 2010 (Hall et al., 2013b). VKU now represent more than 1400 stadtwerke, with about 800 involved in energy supply and generation (VKU, 2013).

There are likely to be a range of reasons for this trend towards the expansion of municipal utilities, including concerns that the private sector has failed to reduce costs and increase efficiency, a re-examination of the relationship between the State and private sector following the 2008 global recession, and an increasingly need for municipal authorities to access revenues from running public services (Wollmann, 2012; Friedländer, 2013). At the same time municipalities in Germany have been developing skills in operating in liberalised markets, are increasing involved in local climate programmes that seek to deliver multiple environmental and socio-economic objectives and can access finance at generally lower rates than fully commercial organisations. In addition, a large number of long-term (25-30 year) distribution concession contracts have or are coming to an end, allowing municipalities to repurchase them (Witte, 2012; Hall, Foxon and Bolton, 2015)

Increasing policy support for CHP and renewables may also have helped to support the growth of municipal utilities as technologies such as biogas production and waste/biomass CHP work best at a municipal, rather than national or individual, scale (McKillip, 2012). Additionally a powerful coalition was formed in the early 2000’s between the European Commission, the federal government and local authorities which positioned local public energy companies as a key strategy for promoting competition with the ‘Big Four’ energy companies (Wollmann et al, 2010). This Federal support included a 2001 stipulation by the Federal Cartel Office that minority interests of external shareholders in stadtwerke must not exceed ten percent, effectively bringing to an end the strategy of the four large energy utilities in Germany of buying up large shares of stadtwerkes (Buchanan, 2012). Finally, the long history and important local economic role of stadtwerke has led many Germans to feel a close attachment to their local utility (Yapp, 2012), particularly as they finance wider public services such as leisure services and public transport. This strong support means they experience lower levels of customer switching than, for example, in the UK and also less opposition to energy price increases (Utilityweek, 2011).

Despite this trend towards remunicipalisation, it should also be noted that stadtwerke are increasingly organised under private company law as limited liability companies (designated as ‘GmbH’ in Germany) or joint-stock companies. This creates stronger separation between the municipality and the stadtwerke as board members are delegated from the local council but council members who are not on the board have little access to information. There is ongoing debate regarding the implications of this more ‘corporatised’ structure for public utilities (see Herzberg, 2013) however studies indicate that stadtwerke are more actively investing in CHP and renewables (Ostertag et al., 2007) and demonstrate a stronger commitment to environmental protection than fully private utilities (Richter, 2013)

This section has outlined a resurgence of interest in heat networks in the context of the Energiewende in Germany, with local municipalities playing an important role in development. There is also evidence of a trend towards increasing municipal ownership of energy and a German transition characterised by multiple actors active, and influencing at, multiple scales (Moss, Becker and Naumann, 2014)**.** In England, there is emerging evidence of a similar, albeit smaller-scale, resurgence of interest in both heat networks and municipal energy companies (see Hall et al., 2014). Table 3 outlines the key targets, regulatory environment and support for heat networks in both Germany and England.

Table 3: Heat network environment in England and Germany

Topic	England	Germany
Heat demand met by heat networks	~2%	~12%
Deployment targets	No formal target but Government documents suggest that at least 20% of heat could be delivered by heat networks by 2030.	No formal target but a target of 25% of heat delivered by CHP by 2020 is in place. This target equates to 18-22% of demand met by heat networks by 2020.
Regulation of heat networks	No formal regulation. Voluntary, industry-led consumer protection and industry standards are in place. The CMA has recommended formal regulation (in 2018).	Ex-post regulation of prices. Technical and customer service standards are set out in law and jointly developed by the government and the AGFW.
Government support for heat network deployment	HNDU provides funding and support for local authorities to carry out feasibilities and business case development (67% of costs). HNIP provides financial support in the form of grants and loans for public and private heat network sponsors (£320m allocated 2017 – 2021) Capital grant funding for heat networks has been available for short periods in the past.	The CHP Act provides a tariff for CHP electricity and grants for heat network pipework and storage (30-40% capital costs). Up to 60% of heat network feasibility costs and 66% of staff costs (for 2 years) available for municipalities to carry out energy planning. National and local development banks provide low cost loans to municipalities to plan, organise, and implement heat networks.

Dominant ownership structures	Diverse - historically an established role for design, build, finance, operate and maintain (DBFOM) concession contracts. To date primarily through Engie (formerly Cofely DE) and E.On. Some established municipally owned networks are in operation in large cities.	Diverse with significant municipal ownership. Complex ownership structures that incorporate public and private investment and/or municipal consortia are common. The four major German utilities all have commercial interests in heat networks, but these tend to be limited to connecting conventional power plant or industrial applications.

2.7 Barriers to deployment

Drawing on academic and policy literature in the UK, Germany and more widely, this section reviews the barriers to the development of heat networks, concluding that many of the barriers to the growth of heat networks are not technical. Instead the challenges fall into four broad topics of (1) coordination and complexity, (2) finance and the business case, (3) energy market structure and, (4) public perceptions. These barriers interact, for example a lack of consumer awareness or trust in heat networks may increase demand risk which increases the cost of capital. As Frontier Economics (2015, p. 3) highlight, this 'suggests that a coordinated policy approach will be required' and a number of analyses suggest that policy intervention will be required to achieve a step change in the rollout of heat networks (Committee on Climate Change, 2015).

2.5.1 Co-ordination and complexity

Developing a heat network necessitates that heat generation, distribution and a customer base (demand) are developed at the same time, in a locally coordinated manner. Projects are also likely to need to engage with the local planning authority, the owner of land through which the heat network is laid and multiple heat customers (Hawkey, 2012a). This complicates both business case development and the negotiation of actor relationships.

In addition, many of the organisations involved may operate at differing scales or with differing levels of involvement in the local scale. For example, while heat customers are necessarily local, international companies may be involved in building, financing or operating heat networks with associated challenges of local-scale actors interacting with national and transnational companies. These local, national and international interests may overlap, presenting particular co-ordination challenges and complex actor relationships (Andrews *et al.*, 2012).

Similarly, a wide range of skills are required in the development of heat networks (including technical, contractual, legal, financial, business development and relationship management), which are often not all held within a 'lead' organisation. In reality, schemes often straddle the competencies of many organisations as they differ from most other projects undertaken by energy developers, commercial property developers and local authorities.

Access to an appropriate range of skills may be particularly problematic for local authorities who do not have in-house energy system skills. This may be particularly the case in England due to the limited role local authorities have played in the energy sector in recent decades.

2.5.2 Business cases and finance

Although the operational costs of heat networks are generally low, high upfront capital costs and low rates of return (compared to other utility scale investments) often make it difficult for schemes to raise capital (International Energy Agency, 2014b). Indeed, the findings of the Heat and the City Project[32] (Hawkey & Webb, 2012) suggest that many commercial investors, including utilities, often require higher rates of return than district heat schemes can offer. This may be due to a lack of experience of heat projects, a lack of standardised business models, a high premium being attached to the risk of the project losing its heat customer(s), and a lack of internalisation of the cost of carbon emissions. Institutional investors who may accept lower rates of return, such as sovereign wealth funds and pension schemes, also find it difficult to invest in heat networks as individual schemes are below the minimum investment thresholds for these investors (DECC, 2013b).

[32] The Heat and the City Project is a multi-disciplinary research project examining the development of low carbon heating in urban areas. See www.heatandthecity.org.uk.

Investors are also sensitive to the risk of uncertain returns on the substantial capital outlays required for heat networks, particularly as significant investment is required prior to connecting customer buildings. To reduce this demand uncertainty appropriate long-term heat off-take contracts need to be secured and this can complicate project financing and increase the cost of capital (UNEP, 2015). In comparison, returns on sunk investments are protected for the regulated gas and electricity networks in both England and Germany. UKERC (2013) suggests that heat networks are therefore forced to compete with regulated assets (such as the gas transmission grid) where there is a mechanism to support network investment.

These difficulties in raising finance may be exacerbated by the volatility of gas and electricity prices and by the interaction of heat networks with multiple other policy areas. For example networks might be impacted by policies as diverse as electricity capacity markets or reserves, renewable heat incentives, CHP policies, domestic and non-domestic energy taxes and the EU Emissions Trading Scheme. Changes to any of these policies, together with inconsistencies between policies, can therefore impact on project viability. The impact of policy uncertainty and policy conflicts is highlighted in studies by Frontier Economics (2015) and Element Energy (2015) who suggested that heat networks are particularly vulnerable to policy barriers in the form of complexity and inconsistencies.

Despite these difficulties heat networks can be financed via a variety of means, often informed by the ownership and operation business models. Project developers tend to be local authorities or housing developers and finance options can be summarised as:

- Self-financing (where the lead organisation is a public body this financing option overlaps with public financing).
- Loan financing (may be partial or total)
- Third party financing. These agreements tend to be with an Energy Service Company (ESCo) who owns, finances and operates the system. This may be for a set period of time or for the life of the project.
- Joint ventures – joint ventures may reduce risks for individual parties.

Each party may fund the project through diverse means.

- Public financing

(Adapted from International Energy Agency, 2014).

2.5.3 Energy Market Structures

In addition to issues regarding finance, the viability of CHP-heat networks is often dependent on the sale of electricity to increase revenues and recoup the large capital outlay (Kelly and Pollitt, 2010). In these circumstances access to the electricity market and the ability to realise close to the wholesale value for exported electricity are significant issues.

A number of studies have considered the issues related to the relationship between CHP-heat networks and the electricity market (see Bolton & Foxon, 2013b; Hawkey et al., 2013; Kelly & Pollitt, 2010; Toke & Fragaki, 2008) and suggest the main issues are the low price of electricity relative to the cost of natural gas (the ‘spark-spread’) and high transaction costs for small generators interacting with national electricity markets. In relation to the spark-spread, as an increasing share of zero marginal cost[33] renewable energies are incorporated into the energy system wholesale electricity prices are likely to decrease further in the future putting more pressure on the financial case for CHP. Regarding transaction costs, for small participants these costs are largely made up of the costs of trading and balancing position on the electricity market and distribution system connection and charging. The existing electricity markets in both the UK and Germany are based on bilateral trading with real-time balance achieved through a balancing mechanism and gate closure system which penalises over and under supply (Elexon, 2013; Just, 2015; van der Veen and Hakvoort, 2016). This results in high costs for small generators, particularly intermittent renewables and heat-led CHP. In addition the credit conditions and complexity of balancing mechanisms make it difficult for small operators to participate (Kelly and Pollitt, 2010).

[33] Marginal cost is the cost of producing additional units of a good or service, outside of fixed costs. As renewable energy sources do not have fuel costs the marginal cost of each unit is zero.

2.5.4 Governance and regulation

Building on issues of finance and complex stakeholder interests, a number of authors suggest that the wider energy system institutional and regulatory structures can act as a barrier to the growth of heat networks. Studies have particularly identified these issues in the UK with Hawkey et al. (2013: 29) emphasising that heat networks are ‘caught in the squeezed middle ground between greater efforts at large-scale national infrastructure investment on the supply side, and individual householder incentives on the demand side’. Kelly & Pollitt (2010), Toke & Fragaki (2008) and Roelich et al. (2013) support this claim and emphasise that the current centralised energy system is not very supportive of ‘novel’ approaches such as heat networks due to the centrally based structures, rules and incentives of the current system, such as the focus on short-term returns and high transaction costs for small generators.

Similarly, Bolton and Foxon (2013, p. 2207) suggest that ‘complex and subtle’ market and regulatory mechanisms lock-out heat networks and that energy regulation processes, including energy market design, rules and networks, are particularly influential in limiting growth. This includes the emphasis on consumer switching in retail markets and rules surrounding business separation and unbundling. This is particularly the case as regulatory regimes in both countries are designed to promote economic efficiency and competition in national infrastructure so is mismatched with city-scale heat networks which tend to be motivated by a broader set of societal goals that go beyond economic efficiency and incorporate social aims (e.g. fuel poverty reduction or regeneration) and environmental concerns (e.g. carbon reduction).

2.5.5 Public perceptions

Heat networks remain uncommon in the UK and there is generally low awareness of them as a form of domestic heating. Likewise, although heat networks are more common, in Germany the higher penetration on multi-family housing blocks where heating services are arranged by housing associations means that awareness of heat networks remains low in many areas. Surveys also suggest that some consumers lack trust in heat networks as a reliable form of heating, and have a perceptions that connecting to a network is difficult and costly (Frontier Economics, 2015).

The locally specific nature of heat networks means that variations in generating mix, consumer profile and network costs can potentially result in widely different consumer prices which can be difficult to either communicate to consumers or effectively regulate. This is particularly the case as assessments of the heat network prices cannot simply compare network prices to the average unit price of gas as heat delivered by a heat network also includes costs related to heat source maintenance and replacement (the equivalent to gas boiler servicing and replacement).

2.8 Conclusion and summary of emerging themes

This section has outlined the history and current development of district heating in England and Germany, and the main barriers to further growth. As discussed the development of heat networks is characterised by complexity with multifarious actor networks and wide-ranging project goals. Additionally the growth of heat networks is taking place in a landscape dominated by gas and electricity networks, resulting in a great deal of uncertainty regarding how heat networks fit within this broader system. This has resulted in substantial experimentation in terms of actor networks, business cases and financing.

As discussed in this chapter there are multiple barriers to the growth of heat networks in England and Germany. Many of these barriers relate to institutional structures, regulation and the broader structures of the energy system and can be categorised under four core themes of:

- The co-ordination of complex actor networks at a city scale
- The development of appropriate financing, ownership and governance structures
- The lack of integration of district heating into the current energy system structures
- Limited public awareness of heat networks.

This chapter has also established that heat network policy is in a period of flux and receiving increased policy attention. A range of actors are involved in heat networks and there are a number of possible development and governance routes, with local authorities likely to play a significant role in most networks. This central but uncertain role for local authorities, together with the complex barriers identified, suggests that the development of heat networks is likely to be a highly contested process with a number of actors and interests seeking to influence the direction of development. This is particularly the case in the UK as local governance structures are themselves in a period of change. In order to explore this complex and contested landscape this research will seek to investigate the development and politics of heat networks in England and Germany, each taking a different approach to the promotion of heat networks. The next chapter outlines the theoretical framework which will be employed in this research and develops a research agenda based on integrating socio-technical transitions and discursive institutional literatures in order to explore the interplay of ideas, scale and institutions in energy transitions.

Whilst England and Germany have very different histories and contexts[34] a number of similarities in relation to a renewed focus on heat networks and municipalities raise a number of questions regarding drivers, the role of different scales of governance and interactions between actors. This research will seek to explore these questions in the UK and Germany; considering how municipal heat networks are framed and shaped by various actors and how this relates to the wider political struggles related to changes between state and market production of services.

[34] The UK, and particularly England, has a centralised governance structure dominated by a Westminster-model political system which privileges elite and industry knowledge but limits sub-national government power. In contrast Germany has a tradition of collaborative policy formation and a federal state system which gives significant powers to cities and municipalities (Geels et al., unpublished; Kuzemko, 2014).

Chapter 3: Theoretical framework

3.1 Introduction

This chapter outlines the theoretical framework which is adopted in the research. The study seeks to examine the role of the city-scale in processes of change in socio-technical systems and it is argued that there is a particular gap in the transitions literature relating to the conceptualisation of regime politics at sub-national scales. This has resulted in limited consideration of the role of different actors at the city scale, process of negotiation and development, and the interplay between local-scale projects (such as heat networks) and wider national and international regimes. A discursive institutional approach to the development of heat networks is therefore proposed. This approach is likely to be particularly appropriate as chapter 2 has already established that many of the obstacles relate to the institutions, regulation and structure of the energy system.

Discursive institutional approaches are interested in ideas as the substantive content of discourse and why some ideas come to dominate while others don't. As outlined later in this section such approaches are particularly suited to exploring institutional change, rather than stability. This perspective conceptualises discourse and institutions as interlinked, with discourse both shaping political action and as a form of agency for political actors. Based on the work of Schmidt (2010) three types of ideas can be defined; policy ideas which shape the options and solutions discussed in relation to a policy issue, programmatic ideas which form the underlying principles of policy including problem definition, policy norms and methods, and philosophical ideas which embody the world views, values and underlying assumptions in the policy process. The analytical approach adopted in this research adopts this framework to consider the development of policy and programmes and how these factors mesh with the deeper philosophical principles and norms of public life. In order to explore these three types of policy ideas, and their relations with discourse and institutions, the analytical stages recommended by Hajer (2006) are adopted which identifies key discourses, actor networks/coalitions, and the institutional practices in which discourses are produced. Combining these two approaches (policy ideas, programmatic ideas, and philosophical principles with discourses, actors, and institutional practices) enables the exploration of the relationship between ideas, discourses, institutions and networks in relation to the development of heat networks.

This chapter is divided into four main sections, the first reviews the literature on socio-technical systems and particularly highlights the Multi-Level Perspective (MLP) as an organising perspective for exploring change in complex technical systems. A number of criticisms of the MLP are identified, relating to the treatment of regime politics and scale in energy transitions, and the development of heat networks in cities is proposed as a useful example to explore these issues. The next section introduces neo-institutional theory and outlines how a discursive institutional approach may provide interesting insights into interactions between ideas, actors and institutions in processes of energy system change. In particular this approach may allow the consideration of how actors at different scales utilise, or are constrained in their ability to utilise, ideas and discourses to shape policy and institutions. The third section discusses, in relation to the previous two sections, the theoretical contribution of this thesis and the final section concludes.

3.2 Social-technical systems and innovation

3.2.1 Socio-technical system transitions

Globally the energy sector is the largest contributor to greenhouse gas emissions (IEA, 2015) and transitioning to a low carbon energy system is widely acknowledged as requiring fundamental system changes which go beyond ‘incremental tinkering with existing systems’ (Hargreaves et al. 2012: 9). However complex systems, such as energy, water, transport and food supply, are not just collections of provisioning technologies but are also embedded in wider social systems and practices (Coenen and Truffer, 2012). So, for example, replacing high carbon energy sources with low carbon sources is not simply a matter or replacing one technology with another but also requires broader changes to norms, practices, and business structures. This recognises that technologies and governing systems co-evolve so consideration of institutions, governance and power relations is also central to understanding change in large technical systems (Lawhon and Murphy, 2011).

Exploring these complex interactions in socio-technical systems, particularly in relation to transitioning to a low carbon energy system, is a rich area for research and an extensive literature has emerged which explores processes of change. Much of this work is focussed within Science and Technology Studies (STS) and builds on insights from evolutionary economics and innovation studies (Nelson and Winter, 1982; Hughes, 1983; Berkhout, Stirling and Smith, 2004; Scrase and Smith, 2009; Geels, 2010), although disciplines such as political science and sociology also have a long history of studying socio-political and socio-technical change.

In seeking to understand the relationships between technological systems and society, Science and Technology Studies are particularly focussed on processes of change and inertia and many approaches draw on Hughes' (1983) influential work on technological change in electricity systems between 1880 and 1930. Hughes presented technical systems as part of complex interrelated technical, social and organisational factors and outlined the importance of systems builders in initial system development. He also set out how, once established, systems are resistant to change due to internal momentum which largely insulates components of the system from external factors. An important part of this system momentum is the development of institutional and economic structures (such as processes of economic appraisal) which favour the current system and lock out alternatives.

Development of these structures and norms result in ‘soft determinism’ (Woodman, 2002: 31) whereby technologies and systems of governance that are perceived as not conforming to broader system ‘logics’ are rejected resulting in path dependent trajectories of technical change which tend to require external shocks to drive radical change. This focus on external shocks as drivers for system change has much in common with the neo-institutional literature discussed later in this section as both highlight the role of exogenous change but have less to say on incremental change and internal drivers for transformation.

Hughes (1983) provides an example of these processes in his account of the ‘battle of the currents’ in the early establishment of electricity infrastructures. In the late 1800’s, both Edison and Westinghouse introduced early electric systems in the United States; Edison’s system was based on direct-current (DC) technology and Westinghouse’s was based on alternating-current (AC) technology. Both systems had various benefits and disadvantages and there was intense competition between the two systems to become the dominant design. This competition was not limited to market-based economic competition and also included both parties seeking to attack the other and develop support with politicians, the general public and academia (Unruh, 2000). As a result of political support, the alignment of other technologies with the AC technology, and various other factors, the AC system eventually developed as the dominant design and ultimately absorbed the DC network. At the time electricity generation and use tended to be rather localised with city power stations serving the local area, however the properties of the AC system allowed long-distance transmission and the dominance of the AC technology promoted the emergence of large, centralised power stations close to sources of fossil fuels. Centralised, fossil fuel power generation then co-developed with energy market structures, financing arrangements, system standards, skills and regulation to lock out both DC technology and more decentralised, low carbon generation. If DC technology had emerged as the dominant design it would have required a more decentralised system of generation and distribution and thus would have co-developed with supportive wider technical and institutional structures (Hughes, 1983; Unruh, 2000).

This co-evolution over time of policies, markets, technologies and social norms results in stable configurations which exhibit strong path dependency where relationships between different elements act to support incremental change along the same technical and institutional paths and lock out alternatives (Foxon, 2011). This phenomenon is well established in evolutionary economics (Nelson and Winter, 1982) and was particularly identified in relation to energy systems by Unruh (2000) who suggested that industrial economies are locked into fossil fuel-based energy systems through co-evolutionary processes of technical and institutional development which create persistent market and policy failures which lock out low carbon alternatives (Maassen, 2012). Increasing scale returns mean that firms are incentivised to pursue production volumes and market share which tends to result in technological convergence. Technological innovation then becomes focussed on specialised refinement of the dominant designs and skills, regulation, standards, supply chains, policies and user practices develop which further reinforce the dominant regime.

An example of path dependency and system co-evolution in relation to the topic of this thesis would be the current UK heat system's dominance by individual gas boilers. This dominance of domestic gas boilers has co-evolved with both wider infrastructure systems, such as a national gas distribution network, and a broader socio-technical system which includes elements such as retail supply competition, the unbundling of distribution and supply and the operation of networks under a regulated asset base model. This current socio-technical system also developed within the framework of gas transmission and distribution networks originally being funded by the state during a period of public ownership. The development of heat networks, and other alternatives to domestic gas boilers, need to be considered in this context as heat networks are essentially monopoly suppliers in their local area and heat distribution networks are currently expected to develop on commercial terms[35].

Whilst Hughes' study of electricity systems was very influential in establishing the complex interplay of social, institutional and technical factors in system change it was also focussed on the development of system stability and slow processes of change. Similarly, initially much of the literature on socio-technical systems focussed on historic socio-technical transitions which tended to take place over several decades and involve largely emergent processes of change, such as the transition to piped water in the Netherlands (Geels, 2005) or the transition from sailing ships to steam ships (Geels, 2002). In common with

[35] Although the UK government is supporting the development of heat networks with grant funding, projects are expected to develop commercial investment proposals.

earlier STS approaches these studies showed that socio-technical systems were largely stable due to path dependency, incumbent advantage and system reinforcement between actors with change characterised as taking place incrementally under normal circumstances, for example through innovations gradually increasing efficiency. However system transitions were demonstrated to take place when this general stability was replaced by a relatively short period of radical change, before a new equilibrium is established.

Building on this focus on short periods of systemic change a ‘transitions’ literature has developed within STS which is specifically interested in examining how large-scale shifts from one socio-technical system to another come about. A ‘transition’ is considered to have taken place when a major change occurs in the way a particular societal function (such as energy) is fulfilled (Geels, 2002; Hargreaves, Longhurst and Seyfang, 2012). Much of this work is particularly focussed on sustainability transitions where change is both time limited[36] and purposive[37] (Smith, Voß and Grin, 2010), examples include the decarbonisation of energy and transport and sustainable food production. These issues contrasts with many historic transitions where the relatively slow speed of change to some extent minimised system disruption as social, institutional and economic changes were able to happen in a gradual manner (Hess, 2014). In sustainability transitions the comparatively rapid and directed nature of change suggests that business, social and institutional structures will have less time to adapt in an evolutionary manner with winners and losers created in the process. This highlights the contested nature of sustainability transitions and the importance of both the politics and governance of change.

In analysing socio-technical systems one of the most influential conceptual frameworks is the multi-level perspective (MLP), originally proposed by Rip and Kemp (1998) and subsequently developed by Geels (Geels, 2004, 2012, 2014; Verbong and Geels, 2007) and others (such as Smith, Voß and Grin, 2010;

[36] In that there is a need to reduce greenhouse gas emissions within short time scales to avoid climatic tipping points. For example analysis of the IPPC global carbon budgets suggests that if emissions continue at the rate seen in 2016 then cumulate global emissions are likely to lead to global temperature increases of over 1.5° in 4 years (Carbon Brief, 2017)
[37] In that the aim of the energy transition – to decarbonise – is already known, albeit with much debate regarding the speed and detailed nature of these changes.

Fuenfschilling and Truffer, 2014). The MLP is one of the key constructivist approaches in science and technology studies (STS), together with technological innovation systems (TIS) and strategic niche management (SNM) (Hansen and Coenen, 2015). The MLP is adopted as a framework in this research as both SNM and TIS approaches tend to focus on radical new technologies and as such are not well suited to the study of well-established technologies such as heat networks. Similarly, although both consider formal and informal institutions, they tend not to specifically recognise the politicised nature of institutional development and maintenance. The MLP therefore better provides for analysis of institutions and actors, and recognises the need to incorporate other theoretical insights in order to better integrate politics and scale into the framework, as discussed later in this chapter. In the case of this thesis the MLP is integrated with a discursive institutional approach.

The MLP builds on earlier transitions studies which recognised that general socio-technical system stability is interspersed with relatively short periods of radical change. The MLP posits that these periods of change take place through the alignment of multiple processes at three levels: niche, regime and landscape (Coenen & Truffer, 2012). Transitions are characterised as dynamic, non-linear processes with periods of change resulting from exogenous sociotechnical landscape pressures (such as climate change or social changes) which exert pressure on existing regimes (such as the current energy system). Regimes are the locus of established practices and associated rules that stabilise existing systems and pressure on these regimes acts to open up ‘windows of opportunity’ that might be filled by novel innovations developed in ‘niche’ spaces (such as renewable energy technologies) (Geels, 2011; Hargreaves, Longhurst and Seyfang, 2012). The framework acts as a heuristic and as a means of structuring complexity, as outlined in *Figure 11*.

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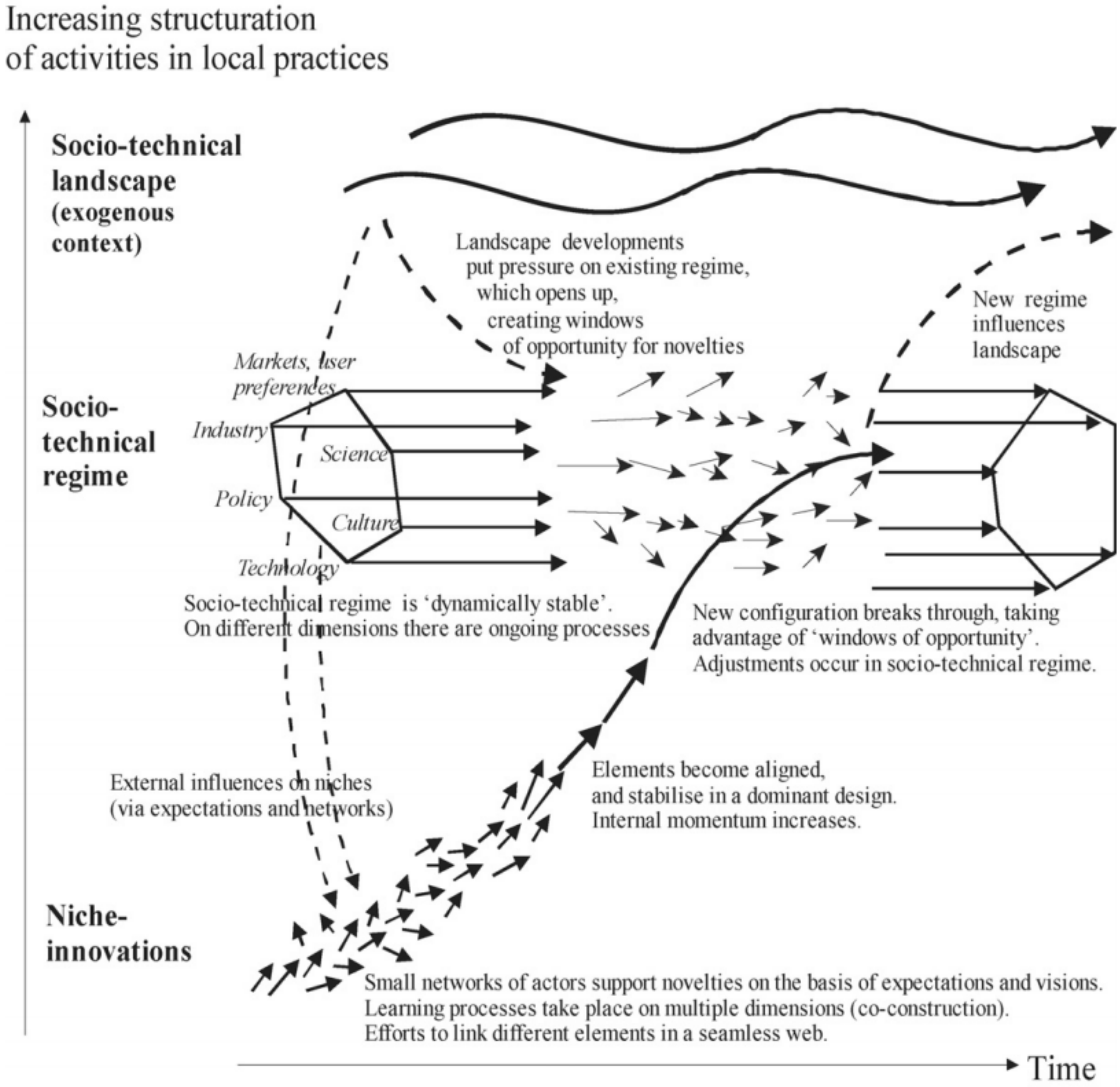
Figure 11: The Multi-Level Perspective



Source: Geels & Schot, 2007

Within the MLP change is characterised as coming about through either (1) changes at the landscape level resulting in sufficient tensions in the socio-technical regime (for example climate change awareness putting pressure on energy system regimes), or through (2) niche innovations managing to establish and grow their networks sufficiently to influence existing regime relationships (an example would be developments in PV and battery technologies resulting in dramatic cost reductions and significant deployment). The relationship between landscape, regimes and niches is however highly complex and recursive with innovations only breaking through to change the wider socio-technical system when multiple processes, across scales, link up and accumulate. An illustration of this is developments in renewable technologies being dependent on both micro-scale niche innovation through R&D as well as landscape factors such as awareness of climate change resulting in national and global policies to reduce greenhouse gas emissions and a market for low carbon technologies.

Recognising that co-evolutionary processes result in path dependency and inertia (Hommels, 2005), the MLP highlights niches as sources of variation which provide the seeds of transitions. The potential for individual innovations to stabilise and grow depends on both internal niche processes, such as learning and efficiency improvements, and the impact of the wider selection environment in the form of regime and landscape dynamics (Geels, 2013; Hodson, Geels and Mcmeekin, 2017). Technological niches tend to initially have difficulty integrating with other elements of the socio-technical system (technologies, institutions, norms). So, for example, the development of domestic photovoltaic systems has historically faced barriers in relation to the structure of existing energy markets, regulatory norms, upfront costs and a lack of consumer awareness. The development of a protective environment is then required in order to allow niche innovations to develop and mature. In the case of domestic PV this included activity such as the development of small-scale feed-in tariffs which provide long-term payments for renewable electricity, grant schemes, R&D by firms which dramatically reduced technology costs and awareness raising activity by NGOs and community groups (KPMG LLP, 2015). While niches are often sites of innovation and change, regimes are characterised by stability through alignment between rules and processes in multiple technical, user, infrastructure, policy and knowledge regimes.

This focus on exogenous windows of opportunity has much in common with neo-institutionalist approaches, as outlined later in this section, however the framework also characterises socio-technical change as a web of complex multi-actor processes (Geels, 2013), with technological transformation situated in relation to wider socio-political-economic systems. This emphasises the role of ‘markets, user practices, policy and cultural discourses, and governing institutions’ as well as new technologies in system change (Geels et al., 2008: 524). Although the MLP has been critiqued for lacking a full conceptualisation of some of issues of discourse, governance and politics (Meadowcroft, 2009;

Kern, Kuzemko and Mitchell, 2014) this demonstrates that the importance of interactions at this level is acknowledged, if under explored. A discursive institutionalist approach might provide a valuable route to exploring these interactions and enriching MLP approaches.

3.2.1.1 Refocussing on regimes

Whilst the MLP is a widely used framework to explore transitions, a number of criticisms have been levelled at the approach. Firstly, although socio-technical transition theorists originally posited niches as the key unit of analysis given their role in innovation and novelty (Rip & Kemp, 1998), there has been increasing recognition by transition scholars of a need to focus attention on the dynamics of socio-technical regimes (Geels and Schot, 2007). Regimes can be defined as the accumulated knowledge, investments, public and private infrastructures, values and norms that form established practice (Smith et al, 2010). The regime level is seen as critical to 'organize the activities and structure the relationships between diverse groups such as public authorities, civil society organizations, users, suppliers, producers, financiers, and researchers' (Lawhon & Murphy, 2011: 358). It is here that processes of norms, rules, practice and governance can create stability and 'lock in' and, in contrast, tensions between actors and networks can open up the system to niche innovations (Van de Poel, 2000). Recognition of the potential for regime reform to produce radical transformations therefore enables exploration of both the role of the incumbent regime in innovation (OECD, 2015) and of how actors are constrained by and influence existing regimes (Geels 2004: 904).

A focus on regime interactions also highlights the role of governance in processes of transition with Kemp and Rotmans (2005) and Loorbach (2007) suggesting that governance processes are important in providing shared visions and goals for transition experiments, providing arenas for those transition experiments and modulating actor network dynamics. It is also important to note that regimes do not operate in isolation and instead a patchwork of inter-related, overlapping regimes exists. This might include science regimes, policy regimes and technology regimes with each regime potentially having differing goals, internal uncertainty and conflict (Geels, 2002, 2004).

The increased focus in transitions studies on regime interaction is also fuelled by arguments that the MLP framework is too functionalist, with regime interactions oversimplified and 'dominated by rational action' (Smith, Stirling and Berkhout, 2005, p. 1492). Smith et al. (2005) and Kuzemko (2013), argue that this has partly led to a lack of exploration of (regime) politics and a 'politics of transitions' literature has developed which seeks to ascribe greater role to power dynamics, ideas and interests at the regime level (such as Meadowcroft 2009; Scrase and Smith 2009; Kern 2012; Smith and Raven 2012; Hess 2014). The next section expands on this growing focus on the politics of transitions.

3.2.1.2 The politics of transitions

The transition to a low carbon, sustainable energy system is widely acknowledged to be highly political as shifts in power are central to change from one system to another (Loorbach, 2007). So the focus is not just about what policies, incentives and practices are in place but why, how and for whose benefit (Lawhon and Murphy, 2011; Mitchell, 2014). In this context there is no neutral steering of transitions as multiple interests aim to influence and shape the future (Smith and Stirling, 2008) and ideas about the 'right' approach to decarbonisation, both in terms of technologies and wider social and institutional changes, are highly contested (Hajer and Versteeg, 2005).

This recognition of the 'messy and complex' politics of policy processes (Sharp & Richardson, 2001: 194) has driven increased interest in the Transitions literature[38] into how existing institutions and discourses influence processes of change. This work is concerned with how existing rules and norms are created or reproduced and the role of argument and persuasion. These themes of discourses and institutions have been brought together by Kern (2009) who, drawing on the work of Schmidt (2008) and Hajer (1995), takes a discursive institutional approach which positions action as taking place within the framework of existing institutions (norms, rules, regulation and customs) which are influenced by (and influence) discursive interactions.

[38] This has also happened across policy studies more generally (see Hay, 2002).

In addition to this emerging focus on the politics of transitions a number of scholars have suggested that the MLP framework over emphasise technological characteristics which results in inadequate conceptualisation of agency and actor dynamics (Hargreaves et al., 2012; Smith et al., 2010). Geels (2011: 29) counters this, suggesting that the MLP framework is in fact ‘shot through with agency’ due to the importance of actors and interactions in trajectories. However Geels (2011) (and others such as Meadowcroft, 2009 and Shove & Walker, 2007) acknowledge that there is a need to further explore the dynamics of both regime politics and actor relations in transition processes.

3.2.1.3 Space and scale in transitions

An additional significant criticism of the MLP is that the framework lacks a full conceptualisation of space and scale (Bridge et al., 2013). As (the city-) scale is a central concern of this research this issue is outlined in more detail below. This is followed by an overview of how a discursive institutional approach might help to illuminate actor dynamics at multiple scales.

Issues of space and scale in socio-technical transitions are starting to generate considerable debate across several disciplines (including regional studies, economic geography, human geography, and international political economy (Raven et al., 2013)), with a range of authors drawing attention to the lack of a sufficient conceptualisation of place and scale in the Socio-technical Transitions (STS) literature (such as Hodson & Marvin, 2010; Lawhon & Murphy, 2011; Smith et al., 2010; Spath & Rohracher,2010; Coenen & Truffer, 2012). Historically socio-technical systems have tended to be presented as consisting of nested, largely autonomous, spatial scales (Rutherford & Coutard, 2014). This criticism has been particularly levelled at the MLP where, although spatial scale is ‘not explicitly conceptualised’, the levels of regimes, niches and landscapes are often ‘implicitly conflated’ with specific spatial scales (Raven, Schot, & Berkhout, 2012:64). Niches tend to be portrayed as local, micro-level features, whilst regimes tend to be represented with national attributes and landscape factors as international/global. This has led much transitions research to privilege the national or supranational scale with cities often characterised as only able to influence niche development and integration. Where the importance of cities in transitions is recognised their role tends to be black-boxed and characterised as merely the space where ‘change happens to happen’ (Rutherford & Coutard, 2014: 1361; Dodson, 2013; Bulkeley & Betsill, 2005).

Empirical studies have also tended to take a national view of actors and institutions which is unclear about the role of sub-national scales[39] and how they interrelate with wider national and societal transitions (Hodson and Marvin, 2010). Certainly a relatively small proportion of transitions studies have explicitly considered the local scale (Raven, Schot and Berkhout, 2012). More recently the literature seeking to explore urban transitions has expanded but there remain calls for further empirical analysis and conceptual development, particularly in relation to the interface between sub-national government and the energy transition (Bulkeley *et al.*, 2016; Cowell, Ellis and Strachan, 2017; Hodson, Geels and Mcmeekin, 2017).

This under-exploration of the role of the city-scale in transitions results in the potential for cities to play a role in shaping socio-technical regimes being underplayed. This limits consideration of the role of different actors at the city-scale, processes of negotiation and development, and the interplay between local-scale projects (such as heat networks) and wider national and international regimes.

Although this is an under-researched area there is a growing body of research which suggests that city-scale initiatives can have an important role in transitions. For example, Späth & Rohracher's (2010) study of the development of Austrian ‘Energy Regions’ suggests that local actors can mobilise distinct ‘discursive niches’ which go on to interrelate with broader energy discourses and potentially influence wider transitions. Similarly, Carvalho, Mingardo, & Haaren (2012), in their study of urban transport and clean-tech innovations, suggest that city-level decision making processes and visions can play an important role in influencing selection environments for international companies.

[39] To date many MLP case studies have focussed on national scale systems, infrastructures and institutions. However transitions can also be studied at an international or urban level.

These examples demonstrate the gradual increase in focus on the role of geography (and cities in particular) in shaping transition processes and recognition of the potential for conflicts and tensions between actors and institutions embedded at different scales (Hodson and Marvin, 2010; Bolton & Foxon, 2013). Despite a slow increase in the number of studies focussing on these issues it remains an under–researched area, particularly as most scenarios suggest that the global energy system is likely to become more decentralised in the future, which suggests that the role of actors embedded at different scales may become more important.

Considering the role city actors and networks might play in regime politics may also provide broader public policy insights as there is much debate in policy literatures regarding the structuration of power within and between various configurations of the state (Hill, 2009). As discussed this perspective is somewhat neglected in transitions literature. These themes are returned to in the results and discussion (chapters 5, 6, 7).

Chapter 2 has already established that heat network projects are likely to be focussed at a city-scale, and this section has highlighted that both regime politics and the interaction of city-scale activities with the wider energy system are under researched areas. The following section elaborates on how analysis of discourses and institutions is likely to help to investigate the politics and dynamics of city-scale initiatives, in this case the development of city heat networks, and sets out a rationale for the adoption of a discursive institutional approach.

3.3 (New)-Institutionalism

Given the limitations of the MLP in accounting for the complex governance and politics of transition processes a number of researchers have suggested that an institutionalist approach may be able to provide insight into transition politics (such as Kern et al. 2014; Kuzemko 2013; Moss et al. 2014). Institutionalist approaches, although diverse, have a long history within political science and seek to elucidate the role that institutions play in the determination of social and political outcomes (Hall & Taylor 1996). This section briefly summarises the differences between early institutionalism and neo-institutionalism. The main schools of thought with neo-institutionalism are then introduced, followed by a discussion of discursive institutionalism.

Up until the 1950's institutionalist approaches were interested in analysing the formal institutions of government and the state and focussed on processes of *government* rather than *governance.* This early institutionalism came under criticism from a range of other schools of thought as lacking conception of the social dimensions and informal conventions that shape institutions. Building on these criticisms a range of alternative theoretical positions started to dominate political science with behaviouralist and rational choice accounts of the role of individuals becoming prominent in studies of political institutions (Lowndes, 2010a). More recently[40] neo-institutionalism has refocused on the role of institutions, recognising that the organisation of political life was still important and, to some extent, bridging the two extremes of traditional institutionalist and behaviouralist approaches. Neo-institutionalism takes a broader view of institutions as social constructs, considering the interplay of different institutions within society and how their dynamics, rules and norms shapes the behaviour and actions of individuals (DiMaggio and Powell, 1991). Within this framework institutions are understood to 'embody values and power relationships' with institutions and individuals interacting dynamically, rather than a one-way relationship of (structural) institutional factors influencing individual behaviour (agency) (Lowndes 2010: 61).

Neo-institutionalism has been referred to as 'bringing institutions back in' to explanations of politics and society (Schmidt 2006: 98) with the overarching term incorporating a wide range of methodological, epistemological and ontological approaches. Additionally, neo-institutionalist scholarship includes a wide variety of conceptualisation of the relationship between state, society and institutions with many different positions on the role of rational action, rules, norms and change in institutions (Lowndes, 1996). Despite this a number of core commonalities distinguish neo-institutionalist approaches from traditional institutionalism. Firstly an expansive conception of institutions is adopted,

[40] Since the 1980's

generally including formal and informal institutions, rules, norms and values; secondly, building on this broad definition of institutions they focus on rules rather than organisations and finally institutions are conceived of as dynamic, social constructs that influence and are influenced by individuals.

While some authors identify up to seven forms of neo-institutionalism, it is generally accepted that four main strands of thought exist consisting of historic institutionalism (HI), rational choice institutionalism (RI), sociological institutionalism (SI) and discursive institutionalism[41] (DI) (Schmidt, 2006; Hay, 2008). While most neo-institutionalist scholars would site their work in one of these schools it is important to note that there are a certain amount of shared features between the four strands and no clear boundaries exist between them (Andrews-Speed, 2016). There is also a great deal of internal debate within each strand and exploration of synthesising the various strands, although the practicality or desirability of this is contested (Hall & Taylor 1996; Hay & Wincott 1998). A brief account of the four schools of thought is given below followed by a rationale as to why discursive institutionalism may provide a better account of institutional change[42] than other forms of institutionalism.

3.3.1 Rational Choice Institutionalism

Rational Choice Institutionalists (RI) highlight the role of individuals as rational, utility-maximising actors in shaping institutions. Here actors are seen to pursue their fixed preferences following a 'logic of calculation' to maximise their preferences (Schmidt 2008b:3). Institutions are conceptualised as setting parameters for action through structures of incentives, but not as determining them (Schmidt, 2010b; Koelble, 2014).

This emphasis on fixed preferences and the stability of institutions gives limited recognition to the role of ideas in shaping political outcomes. As such rational choice institutionalism has arguably the least in common with discursive institutionalist approaches, although some scholars have sought to integrate RI approaches with historical institutionalism in order to better account for

[41] Also referred to as ideational or constructivist institutionalism by some authors (Hay, 2008)
[42] Particularly in relation to socio-technical/sustainability transitions

endogenous institutional change (Schmidt, 2010b). Despite this RI approaches are overtly focussed on the role of individual interests and this might be particularly problematic in explorations of transition politics where an individual's interests might not always be easily 'knowable' or may be uncertain as new technologies or configurations of actors become important. During such periods interests and values (and existing institutions) are often in flux and therefore do not fully account for system change (Kern, 2009). This does not suggest that interests do not matter in transitions but that ideas as well as interests may be important.

3.3.2 Sociological institutionalism

Rejecting the utilitarian, rational choice model of change, sociologists see institutions as dependent upon social and cultural variables, and the individual as a rather unimportant variable in institutional change (Koelble, 2014). Developing this approach Sociological Institutionalism (SI) sees the state as socially constituted and emphasises the importance of culture in determining institutional structures (Schmidt 2006). A broad conception of institutions is adopted that includes values, rules and norms and political agents are characterised as acting according to culturally specific 'logic[s] of appropriateness' (March and Olsen, 2008). This results in processes of institutional change progressing to 'enhance the social legitimacy of the organisation' rather than due to efficiency maximisation behaviours (Hall and Taylor 1996: 949). Institutions are characterised as resistant to change, with change coming about from external shocks or changes to the cultural underpinning of institutions.

Schmidt (2010) argues that the focus on norms, frames and meaning in SI means that ideas are at the basis of the approach however in reality SI scholars vary widely in the extent to which they attribute an explanatory role to ideas with many seeing ideas as culturally determined and static. Sociological institutionalism has also been criticised as overly focussed on rule-following rather than process of rule-creation and also has limited ability to account for contention in political processes (Kern, 2009). Additionally, sociological approaches are likely to have a particular blind-spot in relation to the role of scale and/or cities in processes of change as they tend assume that 'closeness in social space' is most important and underrate the role of spatiality (Fuchs & Hinderer 2014: 355).

3.3.3 Historic institutionalism

Of the strands of neo-institutionalism, historical institutionalism (HI) is theoretically closest to discursive institutionalism as it is centrally concerned with how institutions shape actor behaviour and seeks to integrate institutional analysis with the role of ideas (Thelen, 1999). Historical institutionalists adopt a relatively broad definition of institutions, including formal and informal rules, norms, routines and ideas. Similarly an expansive conceptualisation of the relationship between institutions and individual behaviour is assumed which sees institutions as both shaping the actions of individuals but also being affected by collective and individual choices through power asymmetries (Koelble et al. 2016; Schmidt 2006). This definition positions HI as very different from rational choice institutional theory as actor preferences are understood to be unstable with institutions dynamically interacting with actor preferences through 'struggles that ultimately reflect inequalities of power' (Lockwood *et al.*, 2016: 314). Institutions therefore 'shape political outcomes by facilitating the organization of certain groups while actively disarticulating others' through both the formal organisation of actor groups and also influencing how actors recognise shared interest (Thelen 1999: 92).

HI's emphasis on institutional setting and history suggests that choices made during the formation of an institution play an important role in determining future policy (Kern, 2009) and attributes an important role to unintended consequences. This suggests that most political change is 'incremental and path-dependent' and highlights how institutions are largely stable and tend to constrain rather than enable political action (Andrews-Speed 2016: 219, Hall & Taylor 1996). Indeed institutional change is characterised by HI theorists as requiring exogenous factors to 'punctuate' institutional stability, often in the form of economic upheaval or political conflict (Blyth, 2006).

This emphasis on institutional setting and path dependency does not ascribe a detailed role to actors and lacks sufficient focus on the relationships between structure (institutions) and agency (behaviour) (Hay and Wincott, 1998). These critiques led some HI scholars to pay more attention to the role of ideas in structuring the relationship between actors and institutions and how this impacts on policy. In this respect Hall's (1993) study of changing political paradigms on economic policy in 1970s Britain is used as a prominent example by several authors (such as Kern 2009; Lockwood et al. 2016). However, although some historical institutionalist thought acknowledges the crucial role that ideas play in shaping policy the emphasis is still on institutional continuity with institutions developing along incremental, path-dependent trajectories. Abrupt ‘critical junctures’ can punctuate this overall stability but processes of institutional and ideational change are not fully conceptualised (Hall & Taylor 1996: 942)

3.3.4 Discursive institutionalism

The term discursive institutionalism covers a relatively broad area of political science research ‘which takes ideas and discourse seriously’ (Schmidt 2011, 683), albeit with often differing emphasis on the two and their analytical function (Schmidt, 2010). Within the DI literature institutions are seen to shape behaviour ‘through the frames of meaning they embody’ and ideas and narratives are used to explain and legitimise political action (Lowndes 2010a: 77). This highlights the importance of understanding how ideas become codified over time and processes of contestation and displacement. Ideas and discourses are viewed as influencing institutions through problem definition, the inclusion/exclusion of actors in the policy process, identification of solutions, and the structuring of which voices are heard. Put simply it is interested in why some ideas come to dominate why others don’t and contends that although 'institutional change is precipitated by agency and influenced by social power relations, the aims and content of attempts to change institutions are driven by ideas’ (Moss et al 2014: 6).

Discursive institutionalism (DI) developed as a response to various criticisms of the other forms of neo-institutionalism, in particular that historical, sociological and rational choice institutionalism are all limited in their ability to explain institutional change. It offers an account of how institutional change happens by focussing on the dynamics of actor preferences, interactions and the development of ideas about ‘what ought to be’ (Schmidt 2008b; Schmidt 2008a). Within DI the focus is on institutions as embodying values and power relations (Gamble, 1995) and thus enabling and constraining political action by actors. A broad definition of institutions is adopted, consisting of the formal organisations, customs and norms which together set the (formal and informal) ‘rules of the game’. This draws on elements of the other strands of neo-institutionalism as policy is acknowledged as socially constructed and institutions have an important role to play in establishing political opportunities for change. Based on this broad conception of institutions discursive institutionalism recognises that institutions and discourses are interlinked. Actors are seen as operating within institutional frameworks (norms, rules, regulation and customs) which are influence by (and influence) discursive interactions. This frames the steering and governing of (energy) systems as a series of ‘struggles’ about meaning which are deeply political (Lowndes, 2010; Feindt & Oels, 2005: 161). So, for example, discourses regarding the ownership of heat networks may influence institutional norms and the choices open to actors but, conversely, existing institutions may also limit what can meaningfully be said and shape debate of alternatives (Hajer and Versteeg, 2005).

Whilst the broad definition of an institution within DI approaches is one of the factors which enables the relationship between discourse, ideas and institutions to be probed there are also some difficulties in adopting such an expansive definition. As Lowndes (2010) highlights taking a wide-ranging definition of institutions as the ’rules of the game’ risks a definition that includes everything that guides individual behaviour and an inability to distinguish institutional factors from other social factors. To address this Hall (1986) suggests the adoption of Standard Operating Proceedures (SOP) where the researcher seeks to identify agreed rules of behaviour, whether explicit or tacit, to distinguish formal and informal institutional rules from personal habits and 'rules of thumb'. To illustrate this Lowndes (2010a: 73) uses the example of UK Parliamentary Select Committees where the style and form of questions may not be set down in writing but is identifiable as a SOP as norms and 'unwritten rules' act to structures behaviour and embodies values and power relationships. In contrast the way a Select Committee Member organises their papers is a matter of ‘personal habit or routine, and does not qualify as an informal institution or SOP’.

Pioneered by Schmidt (2010) DI approaches define three types of ideas; *policy ideas* which shape the options and solutions discussed in relation to a policy issue, *programmatic ideas* which form the underlying principles of policy including problem definition, policy norms and methods, and *philosophical principles* which embody the world views, values and underlying assumptions in the policy process. Together these three types of ideas are seen to construct institutional structures and processes of change through ‘the interactions of actors, talking, arguing, making sense of the world around them’ (Schmidt 2010: 3). Hay (2008) suggests that the core contribution of DI is its conceptualisation of institutions as codified systems of ideas with the focus on the interactive processes that generate ideas and how they are communicated and disseminated by actors. This highlights not only processes of communication but also ‘the institutional context in which and through which ideas are communicated via discourse’ (Schmidt 2008a: 3).

In addition to the three levels of ideas (policy, programmatic, philosophical) outlined above, Schmidt suggests that ideas can be categorised into two types, *cognitive*[43] and *normative*. These overarching ideas often tie together the three levels of policy, programme and philosophy with cognitive ideas concerning ‘”what is and what to do” whereas normative ideas indicate “what is good or bad about what is” in light of “what one ought to do”’ (Schmidt 2008b: 306). Cognitive ideas are used by political actors to justify policies and programmes and act to define the problems to be solved, the methods to solve those problems and how policies can offer solutions to problems (Lorenzoni and Benson, 2014). Normative ideas evaluate options for action and help to legitimate policies and programmes through reference to how they resonate with deeper societal philosophical principles and norms.

[43] sometimes called causal ideas.

3.3.4.1 Discursive institutionalism in relation to other institutionalist approaches

Discursive institutionalist approaches have a number of core similarities to other forms of neo-institutionalism including a common interest in investigating the relationship between agents and institutions in order to understand institutional change (Lowndes, 2010b). In striving to do this all strands of neo-institutional theory suggest that institutions are important in shaping actor behaviour and action, although they differ in relation to the role they attribute to the relationship between institutions and ideas (Bell, 2011). Additionally all suggest that agents are constrained by their institutional environment resulting in institutions that are path dependent and deterministic. However advocates of DI suggest that focussing on the interplay between actor dynamics, ideas and discourse in shaping institutions enables DI to better account for how institutional change happens. As discussed, explanations of change are often a weak point for neo-institutionalism due to the characterisation of institutions as stable and path dependent (Schmidt, 2010).

Additionally, Van Der Heijden (2010, p. 239)[44] suggests that much institutionalist thought has tended to take a polarised view on many of the issues central to political and social science, for example by studying structure or agency, endogenous or exogenous variables, stability or change. Adopting one perspective for these issues can 'limits one's findings and thereby one's understanding of what is going on', however this research suggests that DI is more nuanced than some of the other forms of neo-institutionalism in that it seeks to integrate structure and agency, incremental and punctuated change, endogenous and exogenous processes. As discussed the three other neo-institutionalisms (RI, SI and HI) all see institutions as largely static and resistant to change with periods of institutional change tending to proceed from exogenous shocks[45]. In contrast DI highlights how internal 'background' discursive processes can drive change and frames processes of change as incremental and dynamic. The key differences between the four strands of neo-institutionalism are outlined below in *Table 4.*

[44] Van Der Heijden refers to Thelen and Mahoney's 2010 book 'Explaining Institutional Change'.
[45] Although some more recent SI, RI and HI work has sought to explore endogenous processes of change the focus still tends to be on exogenous shocks in the context of general stability.

Table 4: The four new institutionalisms (Source: Schmidt 2010)

	Rational choice institutionalism	Historical institutionalism	Sociological institutionalism	Discursive institutionalism
Object of explanation	Behavior of rational actors	Structures and practices	Norms and culture of social agents	Ideas and discourse of sentient agents
Logic of explanation	Calculation	Path-dependency	Appropriateness	Communication
Definition of institutions	Incentive structures	Macro-historical structures and regularities	Cultural norms and frames	Meaning structures and constructs
Approach to change	Static – continuity through fixed preferences, stable institutions	Static – continuity through path dependency interrupted by critical junctures	Static – continuity through cultural norms and rules	Dynamic – change (and continuity) through ideas and discursive interaction
Explanation of change	Exogenous shock	Exogenous shock	Exogenous shock	Endogenous process through background ideational and foreground discursive abilities
Recent innovations to explain change	Endogenous ascription of interest shifts through RI political coalitions or HI self-reinforcing or self-undermining processes	Endogenous description of incremental change through layering, drift, conversion	Endogenous construction (merge with DI)	Endogenous construction through reframing, recasting collective memories and narratives through epistemic communities, advocacy coalitions, communicative action, deliberative democracy

RI = rational choice institutionalism; HI = historical institutionalism; DI = discursive institutionalism.

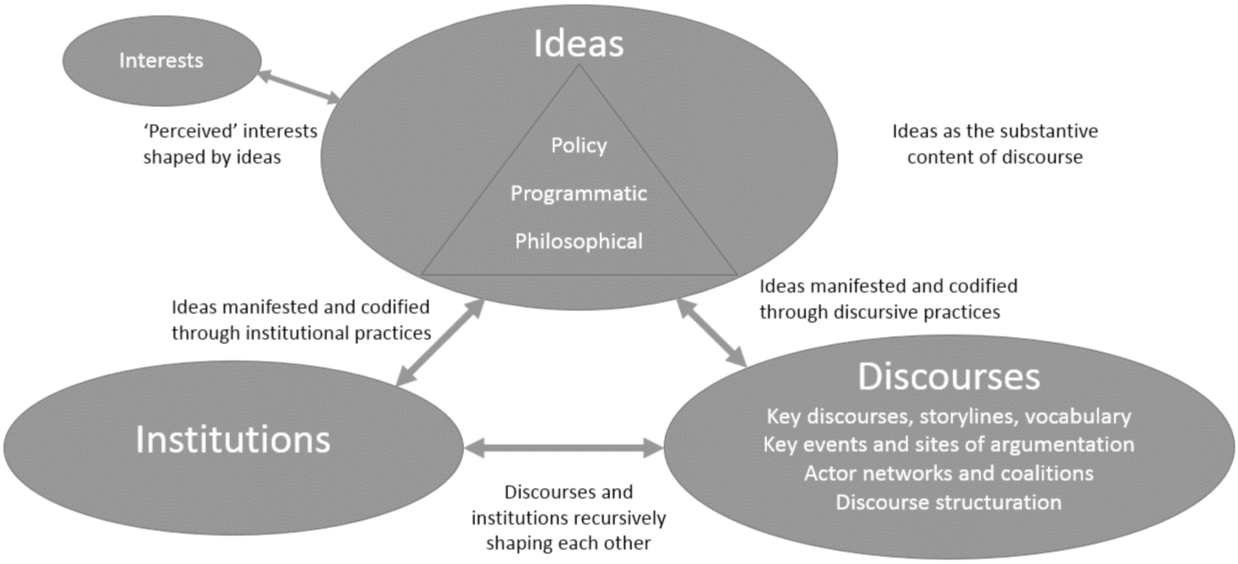
(Schmidt, 2010b)

Although neo-institutionalist approaches are characterised by extensive debate regarding the precise stance of each variant in relation to the meta-theoretical issues discussed above, equally their common, broad definition of an institution recognises that norms, individual interests, ideas, institutional structures and so on are all important and in reality many scholars utilise a mix of approaches and seek to take a non-binary method. It is proposed that studying these issues at a city-scale may provide new insights into interactions between binary issues such as structure/agency or ideas/interests, and the aim of this thesis is to both add to the theoretical debate on the relationship between ideas, discourses and institutions but also to add to policy-relevant knowledge in relation to urban energy transitions.

In summary, a discursive institutionalist conceptualisation of ideas suggests that discourse plays an important role in the generation, acceptance, legitimation and communication of ideas and proposes that these processes are intimately interlinked with the development of new institutional practices and norms[46] (Lorenzoni and Benson, 2014). This advocates that explaining the origins and development of political institutions requires an understanding of how ideas become codified over time and the conditions under which underlying ideas are ‘contested, challenged and replaced’ (Hay 2002: 65). The interactions between ideas, discourses, interests and institutions as defined in this research is illustrated in Figure 12. These relationships are discussed further in chapter 4, where the operationalisation of the research approach is outlined.

[46] And the maintenance of existing structures.

Figure 12: Ideas, discourses and institutions



The next section outlines the definition of discourse adopted by this research and introduces how analysis of discourses will be integrated with exploration of processes institutional change.

3.3.4.1 Defining and analysing discourse

In studying policy processes several authors have highlighted the importance of discourse with Fischer (2003: x) describing politics as 'a struggle for power played out in significant part through arguments about the 'best story''. Numerous studies have also shown that new problem framings or storylines can trigger political and policy change (such as Stevenson, 2009; Bulkeley, 2000; Dryzek, 2005) reinforcing the idea that 'discourses are bound up with political power' (Dryzek, 2005: 9).

Although the term 'discourse' has multiple meanings, within this research both Dryzek and Hajer's definitions are adopted. Dryzek (2005: 9) describes a discourse as 'a shared way of apprehending the world. Discourses construct meanings and relationships, helping to define common sense and legitimate knowledge. Each discourse rests on assumptions, judgments, and contentions that provide the basic terms for analysis, debates, agreements, and disagreements' (Dryzek, 2005: 9). Similarly Hajer (1995: 44) defines discourse 'as a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of social practices and through which meaning is given to physical and social realities'. Both of these definitions take a view that discourse is not synonymous with discussion. Instead discourse goes beyond the linguistics of grammar and syntax and refers to the stories and concepts that structure discussions (Hajer & Versteeg, 2005). An additional important commonality between these definitions is that discourses have coherence beyond the text and thus the meaning of texts can affects outcomes, laws and institutions and *become* the context in which an issue can be discussed. More specifically, in a DI context, discourse is seen as 'the interactive process of conveying ideas' (Schmidt 2008b: 303) and is characterised as arising in two forms; the coordinative discourse among policy actors and the communicative discourse between political actors and the public. Coordinative discourse tends to happen first and acts to generate policy ideas; communicative discourse then allows policy to be developed, communicated and consulted upon with the public. Problem framing, storylines and actor coalitions are important in both stages and discourses need to be cognitively and normatively appealing (Lovell and Bulkeley, 2009).

3.3.4.2 Applying a DI approach

As outlined, within DI three levels of ideas can be defined; specific policy related ideas, general assumptions and principles (programmatic ideas) and implicit philosophical ideas (Gillard, 2016). This research analyses these levels of ideas in relation to heat networks in England and Germany and considers how different forms of ideas are manifested and codified through discourses and institutional practices. To structure the analytical process the stages recommended by Hajer (2006) were adopted which involved identifying key discourses, actor networks/coalitions, and the institutional practices in which discourses are produced.

The first stage in Hajer's (2006) approach to analysing discourse focusses on identifying discourse terms, storylines and coalitions. This involves analysing vocabularies, storylines and metaphors as representations of arguments and ideas. The next stage involves identifying actor networks and coalitions. A shared storyline used by a group of actors can be defined as a discourse coalition and can be identified by the use of the same vocabularies, storylines and metaphors over an identifiable period of time '*in the context of an identifiable set of practices*' (Hajer, 2005: 302, italics in original). Although they share a storyline in relation to a specific issue, actors in a coalition may never have met and may have widely varying interests and world views. For example heat network manufacturers and local authorities may share a storyline of the benefits of heat networks for regeneration and fuel poverty objectives despite having very different motivations for doing so.

It is also necessary to establish if a discourse is dominant, referred to by Hajer (2006) as discourse structuration (when discourses are widely used by a number of actors) and discourse institutionalisation (when a discourse becomes codified in institutional structures). Analysing discourse coalitions can be helpful in exploring discourse structuration as they can indicate the location of commonalities in storylines between actors and which storylines and discourse are most widely used. Discourse institutionalisation refers to how rules, structures, norms and practices interact with discourses and these interactions might take place through the establishment of new organisations or policies (or maintenance of existing ones), or conversely, the failure of an innovation or approach (Hajer, 1995). In relation to this study the institutional practices in which discourses are produced could include such things as access to decision makers, policy paradigms and the processes for adopting new policies. The detailed application of this staged analytical approach to discourse analysis in the context of the DI conceptual framework is expanded in detail in the next chapter.

3.4 Contribution

3.4.1 DI and transition studies

Adopting a DI approach in transition studies, particularly with the objective of exploring regime politics, may be useful as it provides a route to explore the 'open-ended and dynamic relationship between actors, institutions and technologies to explain the obduracy and adaptability of socio-technical systems' (Moss, Becker and Naumann, 2014, p. 5). Transitions studies are also specifically interested in processes of change in socio-technical systems and DI is best suited of the neo-institutionalist approaches to understanding emergent process of change, where endogenous and exogenous factors combine to form new governance systems. Additionally DI scholars such as Lowndes (2005) suggests there is 'creative space' between institutional stability and volatility where entrepreneurs can adapt the rules of the game to address change or to protect their interest. This provides scope to integrate DI and MLP approaches as both highlight the role of experimentation in institutional change, with change resulting from novel combinations of old, new, formal, informal, internal and external institutions.

Analysing policy discourses may be particularly helpful in illustrating how different ideas and rationalities are used in the policy process to frame the sorts of knowledge which 'count' as valid statements within the policy process and therefore become imbued with power (Stevenson, 2009). This allows interrogation of issues of power and politics which can be notoriously difficult to explore, partly as power relations are constantly being produced and reproduced (Flyvbjerg, 1998). Hajer (1995) suggests that analysis of storylines can allow the deduction of various discourse rationalities, such as which technologies are most appropriate, together with analysis of how these stories are represented by different actor coalitions and to what ends. This counters the argument that power and interests matter more than ideas in politics as political action is seen to be 'constituted by discourses…embedded in institutions' (Kern 2009: 37) with ideas manifested in institutional structures, political rhetoric and practices. Indeed, the policy studies literature attributes an important role to narratives, discourses and ideas in processes of policy or institutional change (Hajer 1995; Laird 2001; Kern 2011). In these studies narratives are shown to be important in attempts to re-shape perspectives in order to change patterns of behaviour and achieve institutional reforms.

3.4.2 City-scale transition politics

As discussed, despite a number of authors (such as Kern, 2009; Hendriks & Grin, 2007; Hess, 2014) exploring the politics of regime interactions in sustainability transitions there remains limited work which has examined these processes at a local authority or city scale[47], and even less has considered the interactions between different scales of action. This research seeks to continue the focus of several transition researchers on the politics of transitions but to apply this in a sub-national context. Heat networks may be particularly interesting in this respect as they tend to link local resources and actors with national and transnational finance, skills and interests. Examining this co-production by a web of state, market and civil society interactions may provide valuable insight into the role of sub-national networks in sustainability transitions (Hawkey and Webb, 2012).

This research starts from a position that (local) initiatives are shaped by multi-level contexts *but* are also able to shape these contexts; i.e. that city scale activities are important in transitions. Local initiatives are therefore seen to be important in shaping transitions but politics, power and discourses are important at multiple scales and need to be better understood. Taking this approach highlights a number of questions in relation to the development of heat networks relating to how complex actor networks are forming, negotiating and engaging with other scales; how wider governance structures (the rules, incentives and culture of the energy system) influence the development of heat networks in different contexts; and, how local heat networks are engaging with, and potentially influencing, wider national and international transition processes. All of these questions are centrally concerned with both how power is exercised at the city-scale in order to influence discourses and outcomes, and with how the wider structures of city governance and the energy system facilitate (or not) heat networks.

Much of the existing literature presents the drivers and barriers to heat networks as apolitical and largely based on techno-economic feasibility and the risk appetite of partners. Although the literature recognises that heat network development is often constrained by the wider energy system there is little analysis of political interactions and the interactions between local/national

[47] It is recognised that a number of authors (such as Bale et al., 2012; Bulkeley & Kern, 2006; Fudge et al., 2012) have explored the role of cities in climate change action, however there is limited work that seeks to explore transition politics at this scale.

institutions and discourses. This research posits that the development of heat networks is highly political and aims to address the gap in the literature regarding both the politics of city-scale initiatives and their interaction with the wider (energy) system.

This focus on studying actor networks, institutional arrangements and ‘discursive dynamics’ at the city-scale is advocated by Rohracher & Spath (2013: 14) who suggest that relating the ‘dynamics of urban politics in its multilevel governance context to the multilevel perspective of socio-technical transitions provides novel conceptual insights’. They suggest this provides the potential to offer greater understanding of the role of cities for energy transitions as dynamics across the levels of niches, regimes and landscapes can be explored, together with wider governance rescaling. Additionally while many authors (such as Rhodes, 2007) have discussed the critical role of local governments in increasingly networked and pluralistic forms of governance there is little analysis of how local actors are developing (or not) these roles in the context of the energy transition[48]. This research will seek to explore these issues through considering two countries with differing local governance structures. Studying two country contexts also allows the recognition that cities are enmeshed more or less strongly in multi-level governance relationships where, for example, cultures of centralisation (UK) or federalism (Germany) condition the nature of multi-level governance relationships (Hodson and Marvin, 2010).

3.5 Summary and research questions

In summary, the development of heat networks is used as a case study to explore regime politics and the role of ideas in transitions from a city-scale perspective. Heat network projects are likely to be focussed at a city-scale and existing literature has established that many of the obstacles to further development relate to the institutions, regulation and structure of the energy system. Additionally numerous studies have suggested that the interaction of

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[48] Although authors such as Rutherford and Coutard (2014), Hodson and Marvin (2016) and Cowell *et al.* (2017) are increasingly working in this area.

city-scale activities with the wider energy system is an under researched area. This suggests a number of salient research questions:

- How are heat networks developing in England and Germany?
  - Which public and private actors are engaging in this scale of energy provision and why?
  - What storylines and discourses are being adopted by actors in the development of heat networks?
  - What discourses are dominant in the different contexts?

- How are heat networks engaging with, and potentially influencing, wider national and international transition processes?
  - How do wider governance structures (rules, incentives and norms) influence the development of heat networks in different contexts?
  - How do city-scale heat network projects interact with national policy and institutions?

- What role do city-scale actors play in shaping the ideational and institutional framework for heat networks in England and Germany?

The next chapter details the research method that was adopted to explore these questions.

Chapter 4: Methodology

4.1 Introduction

This thesis undertakes an exploration of the role of ideas and discourses in city-scale energy transitions in order to better understand the interaction of regime politics at multiple scales. The development of heat networks is used as a case study to explore these issues and a range of specific case studies locations are analysed. This chapter justifies the research design and outlines the methodology adopted in the research, including the process of method selection, methodological limitations and the analytical approach.

The overall methodological approach involved three main stages: (1) a review of national heat network policy and discourses in England and Germany; (2) a review of the development of heat networks and associated discourses in a series of case study city locations; (3) a series of in-depth interviews with a range of local, national and international actors involved in heat network development and delivery. Each of these elements of the research approach is discussed in more detail below. The process of analysis is then summarised in section 4.4.

As discussed in chapter 3, ideas can be understood to interact with the policy process at three levels; policy ideas which shape the options and solutions discussed in relation to a policy issue, programmatic ideas which form the underlying principles of policy including problem definition, policy norms and methods, and philosophical principles which embody the world views, values and underlying assumptions in the policy process (Schmidt, 2010). In order to explore these three types of policy ideas, and their relations with discourse and institutions, the analytical stages recommended by Hajer (2006) are adopted which identifies key discourses, actor networks/coalitions, and the institutional practices in which discourses are produced.

The next section discusses the ontological and epistemological foundations of this research in order to contextualise the research approach adopted.

Following this the stages of research are outlined in section 4.3, followed by a discussion of the analytical stages undertaken (4.4). Sections 4.5, 4.6 and 4.7 detail the process of country, case and interviewee selection respectively. Finally validity and the limitation of the approach are discussed.

4.2 Epistemology and ontology

In order to clarify the intellectual underpinning of this research this section briefly discusses the main ontological and epistemological assumptions made. Although it is recognised that this 'allocation of different research approaches to discrete intellectual boxes is an inevitably artificial process fraught with subjective bias' (Jarvis, 1998: 107 in Gofas & Hay 2010a) it is also important to clarify the foundations of the research in order to unpack what the research is aiming to achieve and to be clear about 'what we can know about the world and how we can know it' (Marsh & Furlong 2002: 18).

Many authors have debated whether political science and policy studies can make positivistic claims of knowledge as per the natural sciences (see for example Ayres & Marsh 2013) and there has been increasing recognition of the limits of a positivistic epistemology in policy studies and growing support for more interpretivist approaches and methods (such as Rhodes 2013[49]). This research aligns itself with this shift and does not seek a predictive, law-like method as per positivistic approaches. Instead a detailed qualitative research approach is favoured in order to unlock meaning. Here the focus is on 'analysis of subjectivity, ambiguity and interpretation' (Ayres & Marsh 2013:646) in order to generate insight into how actors construct and reconstruct the world.

As outlined in chapter 3 this research is interested in how discourses and ideas interact at different scales in order to influence institutional change. As such it is based in a principally subjective ontology that sees perceptions as shaping reality and 'facts' as socially, culturally, historically located (O'Gorman and MacIntosh, 2015). Similarly a broadly constructivist epistemological position is adopted however it is also recognised that such categories are relatively

[49] The re-turn to ideas in much of political study can also be seen in this context.

arbitrary with a spectrum existing from extreme rationalist, positivist approaches to extreme post-modern constructivist approaches where ‘the Earth is flat if you say so’ (Osterud 1996:389). Thus, although a constructivist approach is adopted the research is interested in the interplay between the discursive and the material (policies, institutional structure and so on) so is not sited at the extreme end of the constructivist, interpretist spectrum. This position is in common with many other discursive institutionalist (DI) scholars as, at its core, a DI approach sees structure and agency as intimately interlinked with both institutions and ideas highlighted as the basic units of study. Although this does not position individuals as the focus of study (as per rational choice approaches) individuals are still central to processes of change and stability as they are ‘affected, and indeed constituted, by their ideational and institutional context’ (Blyth 2002: 307).

At a meta-theoretical level a dualistic approach is adopted more generally. As outlined by Gofas & Hay (2010a) a number of persistent dualisms exist in political analysis which they argue limit attempts to understand the role of ideas in issues of power and politics. They separate these dualisms as ontological (structure/agency), epistemological (causal/constitutive logics – or explaining/understanding) and methodological (quantitative/qualitative). They go on to suggest that these are not actually independent entities or variables and instead should be seen as intertwined and interrelated rather than dichotomous. So, in relation to this thesis, although a DI stance is adopted it is not suggested that *only* ideas shape outcomes or that material, structural factors (or indeed individual interests) are insignificant. Instead, in line with Marsh (2010:213) and Gofas and Hay (2010a) a position of ‘interactive and iterative’ relationships is adopted in relation to the meta-theoretical issues of structure/agency and material/ideation. This approach is not contentious in DI thinking with Schmidt and Radaelli (2004) suggesting that analysis of ideational variables should take place in the context of institutional and interest-based variables with a recursive relationship existing between ideas, interests and discourse. So, for example, although ideas - manifested through discourse - shape the development and maintenance of institutional structures, institutional structures can also shape what can meaningfully be said and act to reinforce or challenge ideas.

Although in much of the debate the terms structure/agency and material/ideational are used interchangeably the focus within this study is on the material and ideational. This clarifies that the emphasis is on the relationship between ideas and material factors such as institutional structures. This dualistic thinking does however raises the question of, if issues such as materiality and ideas are intertwined, how is it possible to study just one element of the relationship? However it is argued that is it possible to distinguish analytically between issues without ontologically distinguishing them. Therefore it is possible to see ideas and materiality as mutually constituted but focus on one in study (Hay 2002). Specifically this research is analytically focussed on ideas but recognises that they are intertwined with interests and structure. This is referred to as analytical dualism by Archer (1995).

This focus on ideas (as embodied by discourses) also recognises that the alternative of looking at interests is not simple as interests are really about *perceived* interests. This highlights that interests are not materially given so there is a process by which actors arrive at different understandings and constructions of their interests. This research contends that this is the role of ideas, so when ideas change then actor preferences can change. Blyth summarises this as ‘ideas generate change through the fundamental alteration of agents’ conception of self-interest’ (Blyth 2002: 42)

In practice this approach means that although a complex dialectical relationship is conceptualised between ideas, institutions, discourse and interest (as outlined in chapter 3 and Figure 13) the analytical process takes discourse as the starting point as illustrated in Figure 14. The focus is therefore on analysing how ideas are embodied in discursive processes, how discourses influence institutions and how institutions enable or constrain what can meaningfully be said.

Figure 13: Interaction between ideas, discourse, institutions and interests

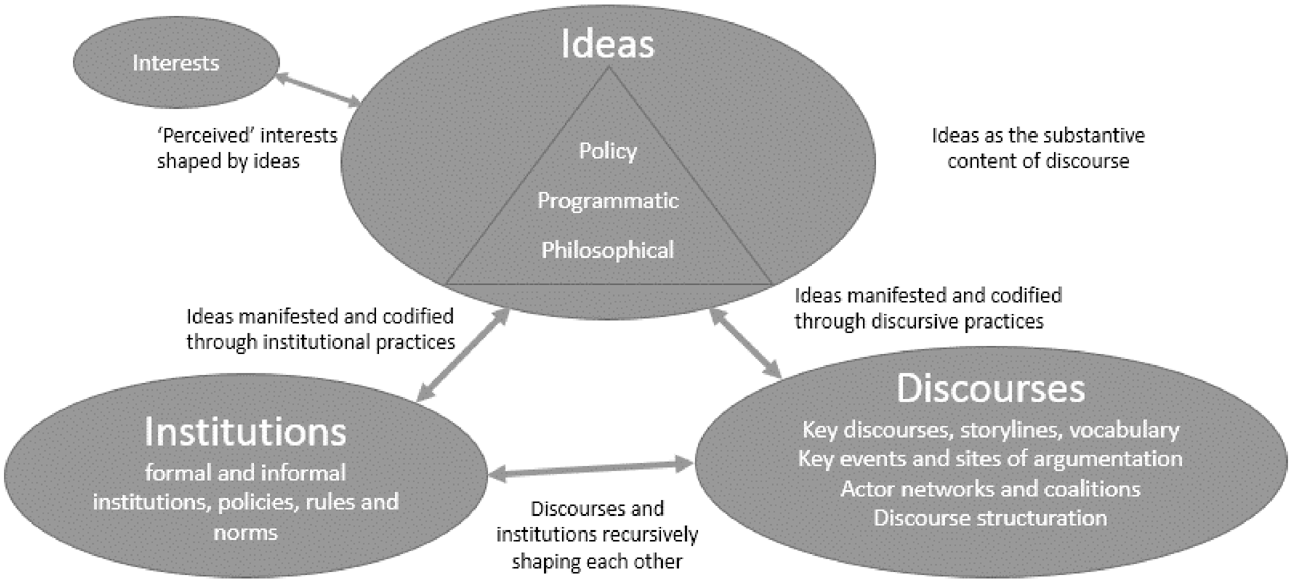


Figure 14: Analytical approach

Now that the core underpinnings of this research have been summarised the following sections outline the key stages in the research methodology, case selection and the analytical approach.

4.3 Research stages

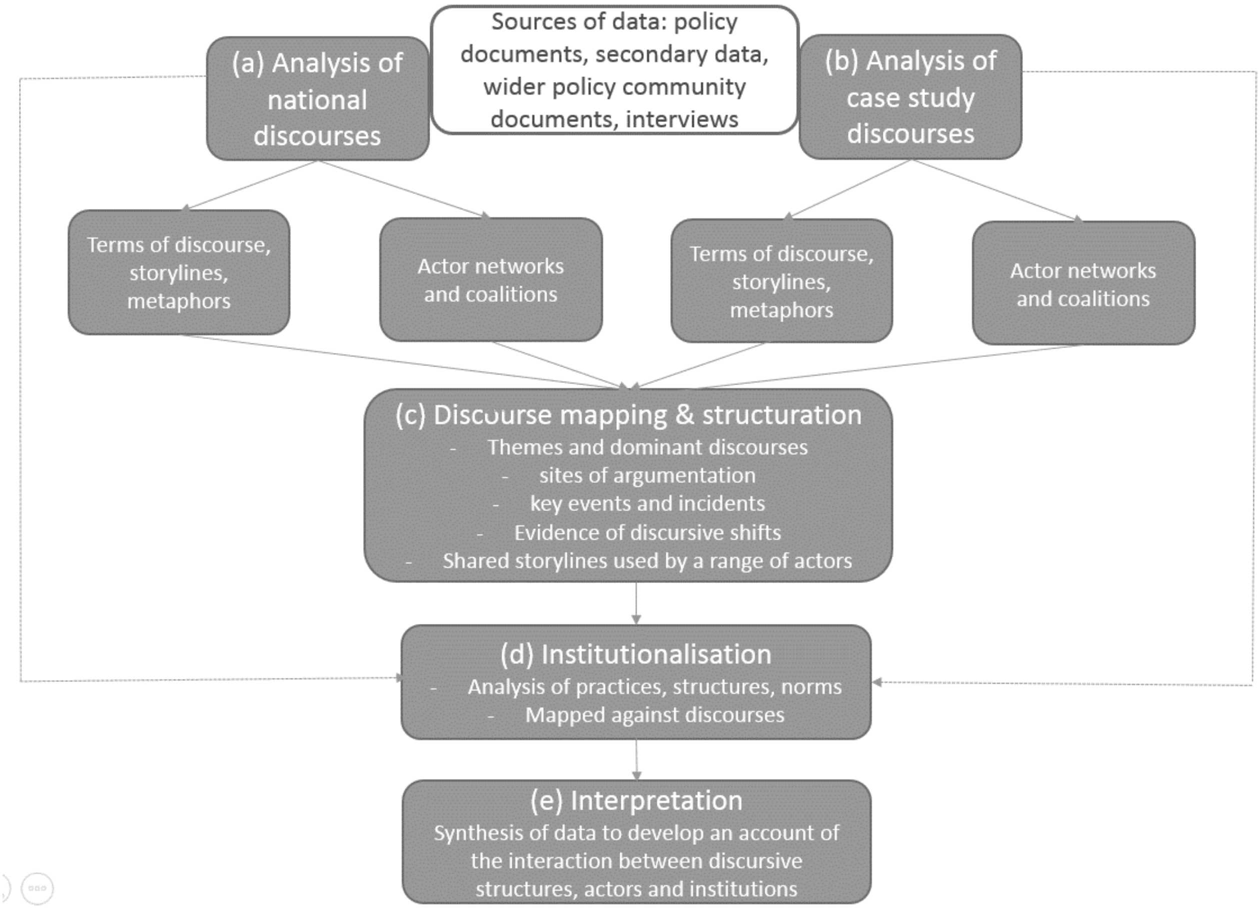
A two stage approach was adopted in this research of (1) a review of national level policy, discourse and actor networks in England and Germany, and (2) a series of case studies in both countries, as detailed below. Both stages incorporated a range of data sources including:

- Government heat network policy documentation (policy documents, consultations and government position papers);
- Wider policy community literature (studies, reports, working papers, press releases);

- Semi-structured interviews.

The research and analytical stages undertaken are summarised in Figure 15 and further detailed in the rest of this chapter. Interviews were carried out between autumn 2014 and spring 2016.

Figure 15: Research and Analytical stages



4.3.1 Review of national level policy, discourse and actor networks

Stage one of the research method involved a detailed review of the development of heat networks in England and Germany. This included analysis of regulatory structures, city governance, heat network ownership models, and wider city-scale (and heat) narratives. This stage aimed to establish the actors engaging in heat network development in the two comparator countries, together with national discourses and the institutional structures of heat networks.

This stage of analysis was undertaken based on documents published between 2007 and 2018 in both countries. This timeframe was selected as 2007 represented a significant year for both countries in terms of the climate and energy policy (with the Integrated Energy and Climate Programme published by the German government and the Energy White Paper published by the UK Government). Limited specific heat network policy was in place in either country prior to this date. Approximately 25-30 documents were reviewed for each country with selection based on a review of key publications from the relevant government departments, significant policy announcements, industry reports, trade association, NGO publications and document searches carried out for reference to ‘heat policy’, ‘heat networks’, ‘district heat’, ‘heat decarbonisation’, ‘cities’, ‘municipalities’ and ‘local authorities’. A summary of this analysis is presented in sections 5.3 (England) and 6.3 (Germany) with further analysis integrated into the rest of these chapters. In addition to documentary analysis 54 in-depth, semi-structured interviews were carried out as described in section 4.7.

4.3.2 Case studies

In addition to national level mapping of policy, discourse and actor networks in England and Germany, a series of case study locations were researched in detail. This again involved analysis of documentary evidence and a series of in-depth interviews in each location. The process for case study location selection is outlined in section 4.6 and interviewee selection in section 4.7.

A case study approach was adopted in this research as the study is concerned with the process by which heat networks are developing at a city scale, and in particular the discourses, politics and interplay between different levels of governance. As this involves a range of complex interactions it is likely to be particularly suited to a multiple case study approach (Flyvbjerg, 2006). This provides the opportunity to explore questions of ‘why’ and ‘how’ and development over time (Yin, 2014: 2). Indeed Kern (2011) suggests that case studies are especially suited to analysing the politics of policy processes and Flyvbjerg (2006) highlights the extensive use of case studies to study power in urban environments.

Case studies are a widely used technique in studies of local climate change governance (Pohlmann, 2011) and Hodson & Marvin (2012: 435) also advocate the use of documentary analysis and in-depth interviews to explore the intersection of socio-technical transitions and urban political economy due to their ability to demonstrate the 'richness and multi-faceted character of…re-scaling an energy regime to a city-regional scale within a broader national state space'[50].

Previous research (such as Hawkey et al., 2013) has already established that local circumstances are very significant in the development of heat networks. It is therefore difficult to make generalisations based on a small number of cases. However there are number of common themes emerging from existing literature regarding systems of governance and actors relations in heat networks (see section 2.6). The use of a case study approach allows the detailed examination of these themes across a number of locations. Additionally one of the main strengths of the case study approach is the ability to draw on multiple sources of data (Yin, 2014) and this research will also draw on wider analysis of the policy context in each of the comparator countries. This aims to develop a broad and holistic account of the complex social and political process (Yin, 1994) involved in the interplay between actors, institutions and ideas in energy systems.

In each of the local case studies the history and discourses of heat networks in that location was analysed based on policy documents, meeting minutes and a range of interviews with local authorities, private sector parties and other actors involved in the development and operation of heat networks.

4.4 Analysis

All interviews were recorded and transcribed with additional field notes transcribed and linked to transcripts at this stage. The interview data was then

[50] In their case this involved a detailed case study of low carbon planning in Greater Manchester.

manually thematically coded and analysed using the qualitative data analysis software NVivo. This allowed the systematic identification of themes, including recurring storylines, arguments and sources of similarity and difference. Once transcripts were initially coded they were revisited in order to refine and extend the coding and ensure that core themes were identified. The themes identified in the interviews were then be mapped against the documentary analysis of policy and discourse to establish commonalities, differences and patterns. The analysis tools incorporated into NVivo facilitated the detailed coding and mapping process as it is possible to annotate and apply multiple codes to data. In addition simple linguistic analysis can be applied, such as word frequencies and the mapping of all references to the same phrase(s).

Following this thematic analysis a staged analysis process was then adopted based on Hajer's (2006) approach. These stages consisted of:

a) Identification of discourse terms, storylines and coalitions: national
b) Identification of discourse terms, storylines and coalitions: case studies
c) Discourse Mapping and structuration
d) Analysis of institutional practices
e) Interpretation.

The operationalisation of these stages in this research are illustrated in Table 5 and figure 15 and described in more detail below. The stages of analysis are labelled as a-e in table 5, figure 15 and sections 4.4.1 – 4.4.4 in order to make clear the relationship between the different stages.

Table 5: Research stages, analysis, and lines of enquiry

Stage	**Activity**	**Type of information**	**Example questions/lines of enquiry**
a, b	Establish key discourses	Storylines, metaphors, vocabularies.	What will the role of heat networks be in the future? What are the benefits/barriers? What should be done to promote heat networks? What ownership and governance structures are most appropriate? Who should be involved and how?
a, b	Establish actor	Actors involved, actors who share	Who is involved, at what scale?

	networks and coalitions	a particular storyline, sites of agreement and disagreement.	Who agrees/disagrees and how are these conflicts playing out? How do actor networks form, negotiate and engage with other scales?
c	Trace discourse structuration	Frequency of use and range of actors adopting. Mapping of discourses against types of ideas (policy, programme and philosophical)	To what extent do (groups of) actors share particular storylines? Which storylines are most widely used and by whom? Which discourses and ideas are used explicitly and which are implicit?
d	Establish the institutional practices in which discourses are produced	Trace the links between discourses/storylines and institutions	What changes have taken place (or failed to take place) to policy, governance structures, regulation, practices and norms?
e	Interpretation	Co-ordination of different stages of analysis and final analysis of links between discourses, types of ideas and ideational power	Link back to main research questions.

4.4.1 Identifying the terms of the discourses (a, b, c).

This stage involved analysing the presence of vocabularies, storylines and metaphors. Storylines encapsulate a discourse in short-hand form to represent complex arguments and concepts. They provide a frame of reference and incorporate metaphors, appeals to emotion, analogies and so on (Hewitt, 2009; Kern, 2009). This level of analysis was carried out through close and iterative analysis of policy documentation, secondary literature and interview transcripts.

Following this a two-stage process was adopted to establish if a discourse is dominant. This approach is widely used in discourse analysis methodologies (Hewitt, 2009) and is referred to by Hajer (2006) as discourse structuration (when discourses are widely used by a number of actors) and discourse institutionalisation (when a discourse becomes codified in institutional structures).

4.4.2 Analysing discourse coalitions and storylines (a, b, c).

Analysis of discourse structuration was carried out through mapping actor networks and analysing the themes and storylines identified in documentary and interview data. This functioned to establish commonalities in storylines between actors and which storylines and discourse are most widely used. Specifically this involved identifying the frequency of use and range of actors adopting storylines and the extent to which (groups of) actors shared particular storylines. This incorporated consideration of sites of agreement and disagreement and the formation and maintenance of actor networks.

This stage of analysis focussed on iteratively reviewing the key storylines and actor networks to review the use of narratives to embody policy, programmatic and philosophical ideas, as detailed by Schmidt (2008). The identification of policy and programmatic ideas in discourses can be operationalised through the identification of 1) debates regarding the role and problem solving power of heat networks, as well as views on how policy should seek to promote them (programmatic ideas) and 2) discussion of solutions and specific policies (policy ideas). It is less straightforward to trace the use of philosophical ideas which refer to the links between (political) ideology and the development of heat networks (Gillard, 2016). This stage therefore focused on both explicit narratives and more implicit themes, as well as storylines which some actors may seek to exclude. An outline of the coding structure utilised, which highlights reference to policy, programmatic and philosophical ideas is include in appendix 4, however it should be noted that the use of the three levels of ideas overlaps considerably and is more fully discussed in the analysis chapters (chapter 5-7).

4.4.3 Analysing the institutional practices in which discourses are produced (d)

This stage involved tracing how rules, structures, norms and practices interact with discourses (discourse institutionalisation). These interactions might take place through the establishment of new organisations or policies (or maintenance of existing ones), or conversely, the failure of an innovation or approach. This analysis was carried out by focussing on references to institutions and practices in the data and exploring how discourses are ‘taken up in actual practice and what sort of institutional innovations it brought about’ (Hajer, 1995: 4).

4.4.4 Interpretation (e)

The final stage of analysis involved drawing together the findings of the previous stages in order to develop an account of the interaction between discursive structures and institutions in relation to heat networks. The analytical processes provided a staged means by which to analyse actors, discourses, frequency of use and contestation and the links between discourse and institutions, however this interpretation stage recognises the significance of interpretation by the research and as such interpretation sought to be self-reflexive and incorporate consideration of how the role of the research influenced both the empirical data gathered and analysis of the links between factors. This was supported by reference back to research notes compiled at the time of each interview and an analytical diary compiled in NVivo which allowed decisions regarding themes and significance of discourses and ideas to be notes and tracked. These issues are returned to in section 4.8.

4.5 Country selection

Two countries are the focus of study for this research; England and Germany. A number of scholars of methods in political research suggest that comparing differing systems or examples may provide the opportunity to ‘acquire a greater understanding of each’ (Burnham et al. 2008: 69). However it should be noted that this study is not a comparative study in the traditional political economy sense as these approaches tend to adopt a variant of the positivistic ‘experimental method’, seeking to compare two cases where a particular stimulus of interest is present and absent. In contrast the focus in this study is on understanding rather than explaining or establishing causation.

Although not selected as quantitative comparative cases, England and Germany have been selected as study countries for this research for a number of reasons. It is not argued that they offer polar examples in relation to heat policy and there isn't an ex ante assumption that discourses in relation to heat networks diverge between the two countries. However a number of themes in relation to political economy, energy system history and heat network development suggest that both cases might provide interesting insights into the role of city-scale transition politics.

Firstly, both countries are pursuing ambitious climate change plans and are aiming to reduce greenhouse gas emissions by at least 80 percent by 2050, compared to 1990. Whilst country approaches to energy transitions are embedded in unique historical, social, cultural and economic circumstances, comparing locations has the potential to illuminate some of the 'universal challenges' of transitioning to a low carbon society (Beveridge & Kern 2014: 12). More specifically, reducing greenhouse gas emission in line with both countries' targets will involve the decarbonisation of their energy systems. Both countries have recognised that heat decarbonisation is lagging behind electricity and there has recently been a resurgence of interest in heat policy in Germany and the UK with both governments seeking to expand heat networks (see chapters 2 and 3). Despite these similarities there are a number of differences in the history, speed, approach and wider governance arrangements between the two countries and this research will seek to explore the similarities and differences in the development of heat networks between the locations, with a focus on the interplay between discourses, ideas and institutions.

Secondly, historically England[51] and Germany have taken differing approaches to energy system liberalisation and privatisation with the UK acting as a pioneer and pursuing early, deep liberalisation while Germany was more reluctant and required prompting from the EU in order to commence energy system liberalisation and privatisation in the 1990s (Auer and Anatolitis, 2014). Additionally, as discussed in chapter 2, prior to privatisation the UK supply sector was centralised and dominated by state owned monopolies whereas in

[51] Although liberalisation and privatisation progressed across Great Britain this thesis specifically focusses on England as heat policy is a devolved policy area in Scotland and Northern Ireland. The policy measures discussed in chapter 2 apply across England and Wales but all the case study locations were in England.

Germany there was a co-existence of public, mixed economy and private companies which were never completely nationalised or centralised (Heddenhausen, 2007).

Finally, from a macro perspective both countries are important examples of modern industrial nations but which exhibit a number of key structural differences. The UK operates a tax funded welfare system, has a centralised, unrestricted political system and is a liberal market economy whereas Germany has a social insurance funded welfare system, operates a consensual political model and is a co-ordinated market economy[52] (Turner and Green, 1998; Bulkeley and Kern, 2006). These structural differences indicate that there may be some differences between the countries at the level of philosophical ideas (as defined by Schmidt 2010), however there is limited existing research considering how these different histories, cultures and policy styles interact with the ideational and discursive shaping of policies at multiple levels, such as heat network policy.

The selection of England and Germany as case study countries does not suggest that other country examples are not valuable or interesting but many of the countries which are commonly studied in relation to heat networks in Europe – such as Denmark, Sweden and Finland – already have a high penetration of heat networks and current policy and debates are shaped by this context making it difficult to look at institutional or policy change. Despite this a number of other countries will be referred to throughout this thesis when discussing specific policy approaches. Equally, despite the focus of this thesis on comparing the policy approach and discourses adopted in the two study countries it is also recognised that there is potentially a great deal of variety in approach within each country and the adoption of multiple case studies within each country aims to explore the extent to which similar discourses and approaches are being pursued in different locations in each country, as well as

[52]In a CME political actors are more likely to pursue dialogue, compromise and trade-offs to achieve unanimous policy decisions. Multiple actors and coalitions therefore have the opportunity to influence policy decisions (Kemfert & Horne, 2013).

the role of sub-national actors in heat network discourses. The next section discusses the process for case study selection in each country.

4.6 Case study selection

As discussed three case study locations were selected in both England and Germany. The rationale behind the case selection was not to choose cases which were deemed to be representative of heat network development in each country but to simply choose cases which were actively developing or extending heat networks (Pettigrew, 1990). In order to explore whether similar discourses and ideas were being propagated in a range of locations and to enable the examination of interactions between different scales within the energy system the cases were also selected based on a number of criteria to ensure a range of actors and circumstances were incorporated. The criteria for selecting the case studies were based on:

1. A review of locations actively pursuing the development or expansion of heat networks[53].
2. A geographic spread of locations (to ensure differing regional styles or political alliances were accounted for).
3. A range of age of heat network or heat network project development. Although all locations were currently developing heat network projects some had a long history of heat networks whilst others were new to their development.
4. A range of heat network ownership structures were adopted or under discussion. This criteria was included as the initial literature review suggested that ideas relating to ownership and the role of different actors might be important in heat network discourses.

Following a review of the above information the case studies outlined in table 6 were selected as representing a wide variation in the location, age and type of heat networks being developed in England and Germany.

[53] In England this was based on information from DECC/BEIS, the ADE and the Heat and the City Project. In Germany it was based on information from Euroheat and Power and AGFW.

Table 6: Case study locations and overview.

England
Bristol Located in South West England. Some small heat networks have historically been developed but ambitious plans are in place to develop new networks as part of carbon reduction ambitions and social objectives. Focussing on public sector anchor loads and mini-networks. Ownership structures are not yet determined but the local authority has recently established a municipal energy supply business.
Birmingham Located in Central England. City centre heat networks have been in operation since 2006 through a concession agreement with Engie. The city is currently looking to develop a number of new networks and is assessing whether to continue with the same model or to develop a new arrangement. Initial networks were closely linked to council climate change commitments and regeneration.
Sheffield Large urban area in Yorkshire. The existing network is one of the UK's oldest and largest. Centrally located energy from waste fuelled network. The main network has gone through various ownership structures depending on the circumstances of the local authority and is currently operated by Veolia. E.On have developed a new biomass network.
Germany
Frankfurt Located in Western Germany. The largest city of Hesse State. Long established heat networks utilising waste, gas and renewables. The city administration is currently pursuing heat network expansion for environmental priorities. Networks operated by a range of organisation with the largest operated through a stadtwerke (Mainova). A complex ownership structure exists but the city has gradually bought back ownership of the stadtwerke.
Hamburg Northern German city-state. Several network are already in operation with the plans to expand the largest network. Heat networks serve 19% of the population and there is an aim to connect 50,000 addition households by 2020. The City of

Hamburg is in the process of buying back the main heat network from Vattenfall following a referendum. Prior to this the municipality held a 25.1% stake in the heat network (Vattenfall, 2014).
Rhein-Hünsruck Rural district in the middle of Rhineland-Palatinate which has developed small-scale rural heat networks. Strong environmental focus for pursuing heat networks. Range of ownership/operation models, including private, community owned and local public utility ownership.

4.7 Interviews

The theoretical approach of this thesis contends that the cause and effect of ideas are very closely intertwined and, as highlighted by Gofas & Hay (2010a), this suggests that analysis of elite discourses are likely to be very important. Interviews are widely used method to access elite discourses and explore complex issues of power and politics (Burnham *et al.*, 2008). Additionally, as already established, a complex range of actors are potentially involved in heat networks and there is a lack of research addressing actors relations, decision making and interactions with the wider energy system. Semi-structured interviews are likely to be effective in exploring such complex and subtle phenomenon as they allow for the exploration of complex topics and also provide flexibility to pursue unforeseen issues as they arise (Flick, et al., 2004; Denscombe, 2010).

Interviews were carried out in person, where possible, or over the phone and were recorded and transcribed. Two visits were made to Germany in order to complete interviews in person. Prior to this communication with key German heat network actors such as the German District Heat Association (AGFW) and the BDEW were developed in order to develop contacts with relevant interviewees and case study locations. Key policy documentation was available in English and few issues were encountered interviewing German contacts in English.

In order to facilitate the collection of reliable, comparable information from across multiple interviews a detailed interview topic guide was prepared as detailed in appendix 3.

As with all research, a number of ethics and confidentiality issues are raised by the research. These particularly relate to interviewee consent, confidentiality and the secure retention of records. To address these issues all interviewees either signed a consent form which outlined the purpose of the study together with data collection terms and use, or these issues were discussed at the beginning of each recorded interview. With consent interviews were recorded and interviewees consented to being anonymously quoted and identified by name in a list of interviewees. In line with this all quotes are identified by number and category of interview but not by individual. Interview transcripts were stored securely in line with the University of Exeter's document retention guidance.

In relation to confidentiality and anonymization, it is important to note that the participants in this study were generally (professional) policy actors and as such are not ordinarily conceptualised as 'vulnerable' interviewees (Allmark *et al.*, 2009). The consent form and verbal introduction to the research both made clear that the study wished to list interviewees and all interview participants consented to be named. However the nature of semi-structured interviews means that is not always easy to identify if sensitive topics are going to be discussed, therefore to facilitate open discussion of key actors, organisations and events the consent form also made clear that the use of the direct quotes would be anonymised. In practice, while few participants expressed concern over their remarks being attributes a minority stated their preference for anonymization of direct quotes and therefore this approach was adopted across all interviewees. A challenge in such anonymization is the possibility that the quotation or contextual information reveals who said what (Lancaster, 2017). To address this participants were offered the opportunity for any identifying contextual information to be removed/anonymised and the opportunity to review direct quotations.

4.7.1 Interviewee selection

The relatively small size of the heat network industry in both England and Germany enabled the main national policy actors relating to heat networks to be identified in both countries through a review of the relevant literature and engagement with policy networking fora (such as the ADE annual conference and membership of the AGFW). As this study in interested in the development of ideas and discourses relating to heat networks at both a national and local scale a range of interviewees were selected to ensure that organisations operating at different scales and with different forms of organisation (such as local authorities, private heat network developers and trade associations) were represented. This involved categorised interviewees as one of nine categories as detailed in table 7. A broadly representative spread of interviewees was then sought across these categories. Some categories, such as NGO, were fairly broadly defined and included both consumer and environmental NGOs.

Table 7: Categories of interviewee and classification in analysis

Category	Abbreviation in analysis
Government	G
Local authority	LA
Consultant	C
Trade Association	TA
Academic/Research	A
DH utility	DHU
Municipal utility	MU
NGO	NGO
Other	O

In terms of local case study interviewees, the specific nature of the research questions (i.e. heat network development in individual locations) suggested a limited range of salient interviewees in each location. Initially these were identified through a desk-based review of the history and development of heat networks in each location. In all cases this indicated a ‘lead’ organisation in heat networks development and provided information regarding key contacts in each locality. National sources such as the HNDU, ADE and AGFW were also used to identify key contacts in each location.

Discussions with these key individuals and a review of the relevant local literature then served to map the actor network involved in heat networks in each locality and identify additional interviewees. In total fifty four interviews were completed, twenty nine in England and twenty three in Germany. Table 8 outlines the interviewees by category and figures 16 and 17 illustrates the split of interviewees in England and Germany respectively. A full list of interviewees in included in appendix 2.

Table 8: Interviewees by category (England and Germany)

Category	Number
Government	7
Local authority	10
Consultant	6
Trade Association	6
Academic/Research	5
Heat network utility	5
Municipal utility	4
NGO	10
Other	1
Total	54
Total UK interviewees	29
Total German interviewees	23

Figure 16: England interviewees by category

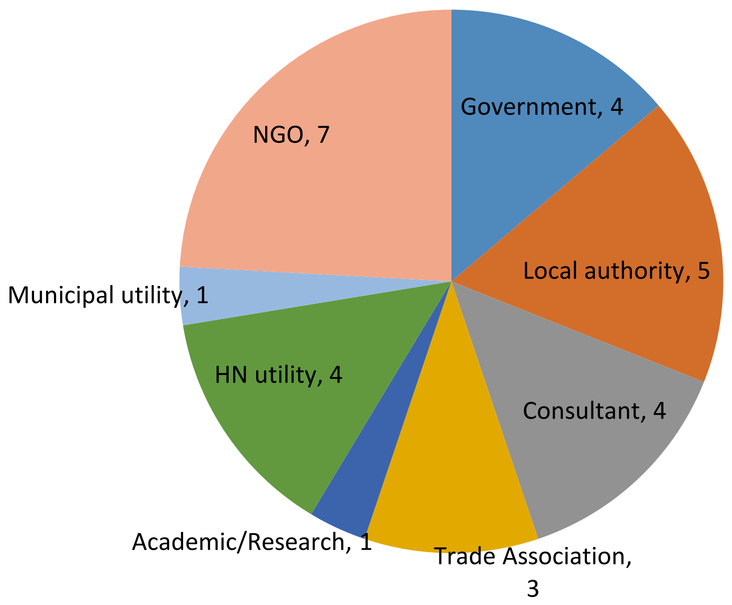
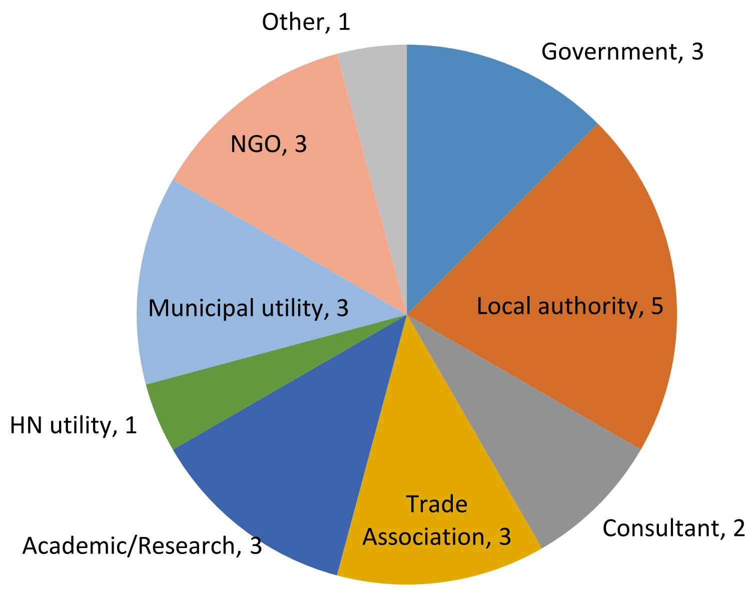


Figure 17: Germany interviewees by category



4.8 Validity and limitations

Case studies are a widely used methodology across the social sciences with Gerring (2004: 341) defining the method as 'an intensive study of a single unit with an aim to generalize across a larger set of units'. However, both case studies and in-depth interviews have been criticised as being unable to provide generalizable learning (Boyce and Neale, 2006). While this may be a wider issue for a range of methodologies that seek to investigate complex, social phenomenon, this research aims to address this criticism by selecting a range of different case studies across comparator countries. This allows data to be collected regarding a range of different circumstances in order to identify themes, commonalities, differences and areas of uncertainty. Yin (2014) suggests that multiple case studies are more reliable than single case studies and are less prone to criticisms regarding single case study generalizability. In addition to a selection of city case studies a number of national and international organisations, who are involved in a wide range of heat network projects, were interviewed.

Additionally, in line with Yin's (2010) process of *analytical generalisation* this research also does not purport to provide findings that are generalizable to across all locations and instead seeks to generalise from case study to theory in order to expand and generalise theory.

An additional criticism of case study approaches relates to the objectivity of researchers, particularly in cases where the phenomenon in question relates to subjectively constructed objects such as discourse. The semi-structured interview method should help to address this issue as interviewees have the scope to shape the direction of discussions rather than the researcher overly influencing the topics. In addition efforts will be made throughout the research to maintain a reflexive approach to, and awareness of, how researcher values and knowledge might impact on the findings. In order to facilitate this reflexivity a wide range of data sources and analysis techniques (such as the staged analysis process described in section 4.4) were adopted. The use of analysis tools such as NVivo also allows more detailed analysis of data than purely manual forms as multiple manipulations of the data can be carried out.

Whilst the above range of actions were undertaken to recognise the subjective nature of studying discourse it is also important to note that this research is sited in a research philosophy that recognises that no actor is objective or value free and does not look for causal explanations. Instead the analysis is centred on subjectivity and interpretation in order to generate insight into how actors construct and reconstruct the world. Indeed, one of the key criticisms of a more subjective and constructivist account of the world relates to validity and subjectivity: 'To positivists, the interpretist tradition merely offers opinions of subjective judgements about the world. As such, there is no basis on which to judge the validity of their knowledge claims. One person's view of the world, and of the relationship between social phenomena within it, is as good as another's view' (Marsh & Furlong 2002:27). Whilst this criticism is partly dealt with by being explicit about the ontological underpinnings of the research a range of actions have also been undertaken to recognise and address these shortcoming. Firstly the research design seeks to explore specific cases in detail rather than to generalise. Secondly, a large number of interviews were carried out in order to ensure varied perspectives and discourses were collected. Thirdly interview data was triangulated with analysis of policy documentation in both countries and case study documentation. Triangulation can be defined as 'is a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study' (Creswell and Miller, 2000, p. 126). This triangulation involved both multiple sources (interviews, policy documentation, industry literature, academic papers and other grey literature) and data from multiple scales (international, national, local).

These multiple forms of evidence were systematically analysed to uncover common themes and areas of differentiation and to provide a structured dissection of the relationship between discourse, ideas and institutions. This analytical process required discourses to be both structured (widely used in relation to topic) and institutionalised (linked to institutional change or stability) in order to be judged to be influential. Additionally the process through which ideas and discourses were identified is discussed in detail in the results and discussion chapters to ensure that the process is transparent.

Ultimately, however, the limits of the research approach must be acknowledged as the findings are largely based on the accounts of participants who inevitably present their own version of reality. The author's own interpretation is also central to the findings and it is accepted that there is a degree of subjectivity in the analytical approach. However, reflecting the ontological underpinning of this research, a perspective is adopted that all knowledge is to some degree subjective so the focus is on the processes by which different versions of reality are arrived at rather than suggesting that one version is more ‘true’ than another. Additionally, in order to support a reflexive approach to analysis both theoretically informed and inductive themes were identified in the analytically process.

Finally, as discussed earlier in this chapter this research does not seek to resolve longstanding debates regarding the comparative importance of ideas, interests and institutions. Instead a more modest aim is adopted to uncover the processes by which ideas, discourse and institutions interact in relation to city-scale infrastructure such as heat networks and how this might have implications for energy transitions at multiple scales.

Chapter 5: Results and discussion – England

5.1 Introduction

The chapter presents and analyses the results of the empirical research carried out in England. This includes exploration of discourses and actor networks, discourse structuration and institutionalisation in line with the analytical stages described in chapter 4. It is based on examination of policy documents, industry reports and 29 interviews with heat network policy actors in England. The chapter is presented as follows; the first section of the chapter summarises the current status and development of heat networks in the three English case study locations of Bristol, Birmingham and Sheffield. This section aims to present a largely factual account of heat networks in each of the case studies together with the broad context for development in each location. The main body of analysis of both the case studies and the national setting is then developed in sections 5.3 – 5.7. Sections 5.3-5.5 outline heat network problem definition discourses before discussing the key established and emerging storylines. Section 5.6 discusses the importance of coalitions and networks in discourse structuration before 5.7 explores how discourses are being institutionalised (or not). Section 5.8 concludes.

The following chapter (chapter 6) then undertakes a similar analysis for the research conducted in Germany and chapter 7 integrates the findings of the two results chapters and discusses how they relate to processes of ideational power.

5.2 Case studies

5.2.1 Case study: Bristol

Bristol's current plans to develop and expand heat networks are led by the city council and are aligned with the authority's commitments to a low carbon future. Plans have been under preparation since the late 2000's with activity increasing from 2005 when the Council, together with public, private and voluntary sector partners adopted a goal to become a European Green Capital (Bristol City Council, 2015a). The development of new low-carbon district heating networks were included in the council's Green Capital application and in 2010 the Council adopted a Climate Change and Energy Security Framework which aimed to improve Bristol's energy security and reduce the council and city's carbon dioxide emissions. This plan included a commitment to develop a range of low carbon infrastructure projects and initial heat network mapping work was completed. At this time an application was submitted to the European Local Energy Assistance Programme (ELENA)[54] for funding to support further low carbon project development. This application was successful and secured £2.5m of grant funding to establish a large scale low carbon investment programme, including the implementation of a city-wide heat network. The ELENA funding enabled detailed feasibility studies for several sites and for consultants to carry out detailed design work on the three most viable projects. Following this preparatory work the Council Cabinet approved further development work on a number of projects in 2014 (Britton, 2015).

Heat networks are identified as contributing to the council's ambition to become a 'sustainable, inclusive, low carbon city' and the council promotes the potential for networks to contribute to both climate change and financial objectives (Bristol City Council, 2015b, p. iii). This enables heat networks to be framed in relation to the city's ambitious target to become carbon neutral by 2050 and to also be identified as an income source for the council, a way of reducing public sector energy costs (such as the council and NHS Trust), and a way of reducing energy costs for social housing tenants (Bristol City Council, 2016a). The linking of projects to both short and long term benefits appears to have supported a phased, long-term planning approach to network development with heat networks described as 'multi-decade major infrastructure project[s]' and a 'cornerstone of the city's journey to becoming carbon neutral by 2050' (Bristol City Council, 2016b).

Although a number of small (social housing) heat networks were already operated by the city council and the University of Bristol and the University

[54] ELENA is a joint initiative by the European Investment Bank and the European Commission under the Horizon 2020 programme. It provides grants for technical assistance focused on energy efficiency, distributed renewable energy and transport projects.

Hospital Bristol Foundation Trust (UHBFT) had previously been connected to a single heat network, prior to the development of the recent schemes there were no substantial heat networks in the city. The city therefore decided to focus on three main projects in the City Centre (Cabot Ward), Redcliffe & Temple (Lawrence Hill Ward) and Rowan (Whitchurch Park Ward) all of which were still under development at the time of this research. The total capital value of these schemes is over £13 million and a range of sources of finance are being considered including several million pounds being secured through Prudential Borrowing[55] (Bristol City Council, 2015b).

City Centre – Cabot Ward

Cabot scheme involves Bristol City Council working with the University Hospital Bristol Foundation Trust (UHBFT) and the University of Bristol to develop a City Centre heat network. The network is centred on the Hospital and University buildings due to their large and relatively steady heat demand, existing familiarity with heat networks and both organisation's commitments to carbon reduction. The Council allocated £5.0m of capital funding through Prudential Borrowing for the installation of this phase of the City Centre heat network. Cabot network involves Bristol City Council installing, owning and operating a gas-CHP generation plant in the UHBFT's existing energy centre. The system will supply UHBFT, adjacent University buildings and council-owned social housing blocks in Dove Street. Connection to Dove Street will replace electrical heating using night storage heaters and aims to reduce costs for low-income residents, as well as reduce carbon emissions. Once this section of the city centre network is complete, it is intended that a wider network will be installed (phase 2) which will connect additional University, commercial and council owned buildings, including social housing.

Redcliffe & Temple – Lawrence Hill Ward

The Redcliff and Temple scheme encompasses the new Temple Quarter Enterprise Zone (TQEZ), social housing and Bristol City Council's offices at 100

[55] Prudential borrowing refers to the rules governing local authority borrowing in the UK. Since 2004 debt is no longer capped by an upper limit and instead must conform to the Prudential Code with regard to affordability (Bailey, Asenova and Hood, 2012).

Temple Street. In March 2016 the first phase on this scheme was completed when a 1MW biomass (wood pellet) boiler was installed and connected to thirteen social housing blocks. The Temple & Redcliffe Heat Network Phase 1 will connect this energy centre to the Council's offices at 100 Temple Street and extend into Bristol's Temple Quarter Enterprise Zone. The network will terminate at the new Bristol Arena and is likely to include supplying a new University of Bristol 'Enterprise Campus' in the TQEZ (University of Bristol, 2017). The project is being funded by a combination of grant funding and Prudential Borrowing and the scheme is accessing Renewable Heat Incentive (RHI) payments (Britton, 2015). The installation of the TQEZ district heating pipework is also supported by funding from the Department of Culture, Media and Sport for General Purpose Service Trench works which also includes private wire and superfast broadband ducting. Temple and Redcliffe are areas of focus for new build developments and the build out of the heat network is being carried out in coordination with other capital projects (such as Metrobus and the Arena Bridge) to minimise capital costs and disruption.

Rowan – Whitchurch Park Ward

In 2015 a wood pellet fuelled heat network was been installed within the Rowan House complex and supplies five social housing blocks, consisting of over 300 flats, in the Hartcliffe area of Bristol. Funding for the Rowan scheme came from the council via Housing Revenue Account (HRA) investment[56] and through an Energy Company Obligation (ECO) contract with an electricity supplier. The project also receives income from the Renewable Heat Incentive (RHI).

Complex actor networks are involved in the development and delivery of heat networks in Bristol, both within the local authority, who is the lead agency, and with external public and private sector organisations. In particular the local authority, University Hospitals Bristol Foundation Trust and the University of Bristol worked together to develop the City Centre scheme. To support this the three organisations signed a Memorandum of Understanding on 5th March 2015 which formalised how the organisations will work together on heat network

[56] Funding for the provision of local authority social housing.

development and committed to a target of initiating works in 2016 (Bristol City Council, 2016a). The city council also emphasised the importance of developing heat networks as part of broader strategic energy planning for a locality. In this involved both developing planning policy that was supportive of heat networks and taking a city-wide approach to energy planning which enables small heat networks to be developed with an aim to interconnect them in the long-term.

A number of interactions with central government were necessary to access funding and other support, this includes engagement with the HNDU team, the heat policy team within BEIS and the Department of Culture, Media and Sport. Relationships with wider national and international groups were also developed including the Core Cities group and European networks such as ICLEI - Local Governments for Sustainability[57], Energy Cities[58] and ELENA[59]. Whilst a diverse portfolio of funding sources has been utilised to develop heat networks the council currently owns and operates the schemes. The development of heat networks also took place at the same time as the development of an electricity and gas supply company wholly owned by the council; Bristol Energy. The long term ambition is to integrate Bristol Energy with local low carbon generation and incorporate the operation of heat networks with Bristol Energy, although the council has not made any decision about integration as yet.

5.2.2 Case study: Sheffield

Sheffield has a long history of heat networks and is one of the largest networks in the UK with over 50km of pipework supplying over 2,800 homes and 140 commercial and public sector buildings (Nolan, 2013). The city is seeking to expand this network and develop new networks and these plans are being led by the city council, although networks are operated under a number of commercial models. The council highlight that the development of heat networks can help meet multiple objectives including carbon reduction, energy security, costs and fuel poverty reduction and opportunities for jobs and growth.

[57] ICLEI is a network of sustainable cities and facilitates local government input to United Nations (UN), processes such as the UN Framework Conventions on Climate Change and Biodiversity.
[58] Energy Cities is the European Association of local authorities in energy transition.
[59] European Local ENergy Assistance Programme

The potential for heat networks to enable further democratisation of the energy system through reduced dependence on national infrastructure is also specifically cited (Nolan, 2013; Almond, 2014). In this context a mini-Stern review[60] was completed for the City Region in 2012 which highlighted the energy spend which flowed out of the Sheffield City Region (Gouldson *et al.*, 2012). Heat networks are framed as one route to maintain energy spend in the region and there is political commitment to develop them further. They are also part of a wider 'Energy – Made in Sheffield' discourse which positions action on energy infrastructure as one way to maintain and develop a vibrant local economy.

The first heat network development took place in the city in the 1960s when a number of blocks of flats (at Park Hill and Hyde Park) were connected to a network based on a central oil fired boiler system. In the 1970s an Energy Recovery Facility (ERF) was built at Bernard Road and waste heat was piped into the Park Hill and Hyde Park network. This reduced the estate's reliance on oil for heating and, at the time, was framed as part of the cities response to the oil crisis with a commitment made to develop a city wide heat network. This led to the establishment of a council owned company, Sheffield Heat and Power, in 1988 who expanded the network and developed the ERF to also generate electricity. In the 1990s the network was further extended into the city centre and to Weston Park, including the connection of both the city's Universities and a large number of private sector buildings.

In 2001 ownership of the incinerator was transferred from Sheffield City Council to Onyx UK (now Veolia Environmental Services) and the original ERF was closed down due to environmental concerns. This followed a campaign by Greenpeace regarding air pollution that branded the site as the 'worst incinerator in England' (BBC News, 2001). A new modern ERF was opened in 2007 and both the ERF and the network are currently operated by Veolia

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[60] A mini-Stern review considers the cost and carbon effectiveness of a range of low carbon options that could be implemented at a city-scale. Analysis explores the scope for deployment, investment needs, financial returns and carbon savings together with the implications for the economy and employment. Several English cities have carried out such reviews, broadly based on the approach adopted in the Stern Review of the Economics of Climate Change commission by the UK Government in 2006.

Environmental Services as part of a 35 year integrated waste management contract with the city council. The network delivers heat to a variety of customers, including the university, the local authority, hospitals, private and public sector offices, and housing. The network serves approximately 3000 residential properties and 140 other buildings.

In 2010-11, the council, together with a range of partners, led a mapping exercise to establish future heat network priorities. This mapping analysed the location of existing CHP plant and district energy pipelines, transport infrastructure, watercourses, building types and heat sources. The council has stressed the importance of this process in establishing priorities and developing working relationships between agencies. The process also involved a wide range of stakeholders including Sheffield City Council, Sheffield Homes, Sheffield International Venues, Sheffield Industrial Museums Trust, Sheffield Forgemasters, Veolia Environmental Services and technical consultants. In addition to this strategic energy planning approach Sheffield City Council is seeking to promote heat networks in new developments through planning policy. The Sheffield Development Framework includes Core Policy CS 65 Renewable Energy and Carbon Reduction which requires that all[61] significant new developments provide a minimum of 10% of their predicted energy needs from decentralised and renewable or low carbon energy; and also reduce the development's overall predicted carbon dioxide emissions by 20% through low carbon energy or design measures (Sheffield City Council, 2011).

In 2013 Sheffield took part in BEIS' (then DECC) Low Carbon Pioneer Cities Heat Networks programme. The project supported five of England's core cities to further develop low carbon heat networks. The support comprised grant funding to cover the costs of feasibility work to investigate the potential for new or expanded heat networks and some access support from experts and policy officials. This support allowed strategic planning work to be undertaken regarding the role of heat networks in the decentralised energy plans of the city

[61] Unless this can be shown not to be viable.

and fed into local authority climate change priorities (Sheffield City Council, 2016).

In 2014 a new biomass CHP plant and heat network, owned and operated by E.On, was opened in the Don Valley. This provides 30MW of power generation and 25MW of new heat capacity. The project was financed by private sector investment and supplies a range of sites with heat including Sheffield Forgemasters, iceSheffield, the English Institute of Sport Sheffield and the Motorpoint Arena (all part of Sheffield International Venues) as well as Attercliffe Police Station. A new 6.5MW waste wood biomass CHP unit is also currently under development on Holbrook Industrial Estate**.** The plant is currently being commissioned and once operational will be managed by Veolia Energy Services. Holbrook Community Renewable CHP plant will generate 6.5 MW of renewable electricity and supply heat to around 6,700 homes and commercial properties. The project is being developed by Sheffield-based firm UYE Ltd and financed by infrastructure investment company Equitix with additional funding from the Green Investment Bank.

Heat networks are part of a decentralised energy vision for Sheffield and the wider City Region. As part of this vision the council aspires to expand, decarbonise and add resilience to the existing network and develop new networks (Almond, 2014). Heat network development was included in Sheffield City Region Investment Fund (SCRIF) proposals[62] so there is opportunity to allocate capital funding to the development of new schemes or the expansion of existing schemes. As part of the city's development plans six new priority areas for heat network have been identified with the 'Lower' Don Valley, 'Upper' Don Valley and extension of the City Centre scheme prioritised.

The development of heat networks in Sheffield, although coordinated by the City Council, is dependent on the investment decisions of commercial heat network operators. This has led the local authority to develop long-term and

[62] The Sheffield City Region Investment Fund (SCRIF) is the City Region's major capital investment fund, made up of devolved Government funding and contributions from local authorities and private sector partners.

detailed relationships with heat sources, network operators, potential heat loads and consultancies in order to ensure that a sufficient evidence base is established to drive growth of the networks. The City council acts as a coordinator to a network of involved organisations including Vital Energy, Veolia, E.On, UYE Ltd, a large range of public and private sector heat customers, the wider city region local authorities and the local universities and technical consultancies. This role includes exploring technical issues in relation to pipe routes and brokering initial relationships with anchor loads. The council has also sought to make a strategic commitment to further developing heat networks in order to give heat network developers certainty regarding the ongoing priorities of the council.

5.2.3 Case study: Birmingham

Heat networks have been developed in Birmingham since the mid-2000s[63] . The city council has led this development but delivery and operation has been in partnership with Cofely District Energy (DE) (GDF Suez and Cofely have since rebranded as Engie in 2016). In the early 2000s the council was actively developing its work on climate change, including participating in the Carbon Trust's Local Authority Carbon Management Programme which facilitated the council to develop a long-term energy strategy and assess opportunities for low and zero carbon energy sources on its own estate. This included the completion of a decentralised energy feasibility study in the city centre, which took place as city centre regeneration plans were being developed (Hawkey, Webb and Winskel, 2013). The feasibility study focused on large organisations that could act as heat loads and identified the Broad Street and Eastside areas as potential locations for heat networks. The Broad Street area includes many large central buildings such as the International Conference Centre, the National Indoor Arena, the Town Hall, the Council House, Hyatt Regency Hotel, the Rep Theatre, Paradise Circus leisure and retail area and New Birmingham

[63] Following successful legal challenges from tenants in the 1980s the council was forced to improve building insulation and heating in a number of multi-storey blocks. As part of the council's response a small CHP heat network was installed but the majority of blocks were refurbished with electric heating. Building engineers within the council started to advocate heat networks from this point (Hawkey, Webb and Winskel, 2013).

Library, and the Eastside area includes Birmingham Children's Hospital, Aston University, Council buildings and the Eastside Regeneration Area.

Workshops were then held with key organisations to discuss the potential for heat networks and the council decided to develop the Broad Street and Eastside schemes (Sustainability West Midlands, 2014). To deliver the first scheme Birmingham City Council, Aston University & Birmingham Children's hospital undertook a joint procurement process which resulted in the formation of Birmingham District Energy Company (BDEC) in 2006 after Engie (then Utilicom[64]) emerged as the preferred bidder for the 25 year contract to operate the schemes. The first 25 year energy supply agreement was signed in December 2006 for the Broad Street Scheme, which was operational in 2007. The agreement for the Eastside scheme was signed in spring 2008 and became operational in two phases in 2009 (Aston University scheme) and 2010 (Birmingham Children's Hospital scheme).

BDEC operates as an Energy Services Company (ESCo) designing, building, financing, owning and operating heat networks across Birmingham. BDEC is a wholly owned subsidiary of Engie and the company directors are employees of Engie. Large subscribers, including the council, sit on the partnership board but do not exercise formal control over the company (Webb, 2012). Engie receives the first 5% of BDEC's profits to cover their costs and remaining profits are split with 50% going to Engie and 50% going to the partnership board members as an energy rebate (Hawkey et al., 2013). Contractual arrangements include provisions for penalties against BDEC for non-performance. The contract also includes a 'joint cooperation agreement' which outlines that the council will actively promote the development of the schemes within the city but that commercial decisions regarding expansion will be made by Engie. The main strategic relationships between BDEC and partners are outlined in figure 18. A number of additional commercial relationships are incorporated into this overarching structure, for instance, in the Broad Street scheme the council directly contracts with BDEC for energy supply, but other public buildings on the

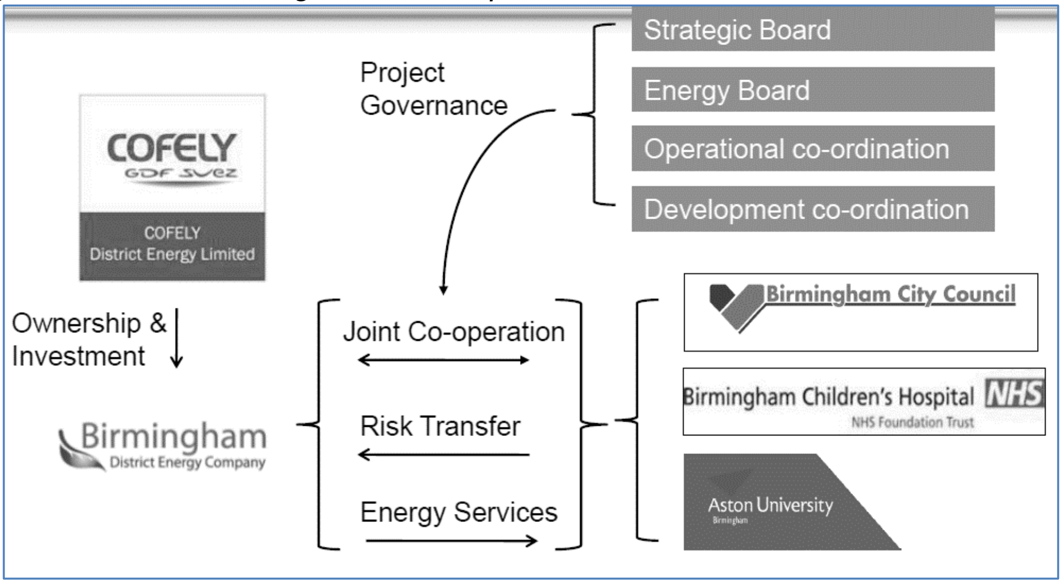
[64] Utilicom was acquired by GDF-Suez in 2010 and its district energy concerns are operated under their subsidiary Cofely. GDF Suez and Cofely were rebranded as Engie in 2016.

Eastside scheme procure energy from BDEC via an energy supply contract with the council in order to reduce complex public procurement costs (Bolton and Hannon, 2016).

The BDEC model of heat network delivery in Birmingham means that project risks are owned by BDEC together with responsibility for existing assets, operational efficiency and new investments. The model was selected as the council adopted a risk-averse approach to the development of decentralised energy in Birmingham. The council highlighted that they had little experience of heat networks prior to the Broad Street scheme and wanted to outsource the risk of developing such schemes to a third party. The council also visited the Southampton district energy scheme that was run by Engie prior to starting the procurement process as this was one of the few large networks in operation in England at the time so were familiar with the contractual structures used by Engie.

Finance for the schemes was secured through equity finance from Cofely and a grant awarded to the council through the government’s Community Energy Programme. More recently a number of multi-storey council housing blocks have been connected, part funded by a Low Carbon Infrastructure Fund from the Homes and Communities Agency and the Council has received HNDU funding to developed further schemes.

Figure 18: BDEC strategic relationships



(Smith, 2012)

The City Council has a strong commitment to reducing greenhouse gas emissions and aims to cut CO2 emissions by 60% by 2026 (on a 1990 baseline) (Birmingham City Council, 2007, 2010). The council suggests that the development of district heating is central to their decarbonisation plans and recognises that potential for heat networks to contribute to fuel poverty and regeneration objectives. Indeed fuel poverty and regeneration were central factors in the development of the Broad Street and Eastside schemes.

Engie suggest that there is a long term aim is to expand and eventually interlink the BDEC schemes subject to commercial criteria (Forsyth, 2014). The Broad Street scheme has already been expanded by BDEC to incorporate heat sources and/or supply a range of other sites in the city centre, such as the New Street Station and John Lewis store. There is also an aspiration to develop biomass, anaerobic digestion and pyrolysis plants to supply heat.

Outside of the BDEC arrangement Birmingham City Council has received funding and support from the HNDU team to identify further opportunities to expand or develop new heat networks. This support has included city energy mapping and energy master planning for the most promising sites. Further feasibility work has also been approved for the Tyseley Environmental Enterprise District where the council want to explore capturing waste heat from the Energy from Waste (EfW) facility. The Tyseley EfW plant is owned by the City Council but operated and maintained by Veolia Environmental Services. The current contract expires in 2019 and the council is considering taking operation in-house (Birmingham City Council, 2014). Several of these potential district heating networks could cross local authority boundaries and Birmingham City Council are liaising with the other local authorities in the Greater Birmingham and Solihull Local Enterprise Partnership (Forsyth, 2014).

5.3 Policy Discourse evolution

As policy to decarbonise heat has risen up the agenda, discussion of heat networks has developed in policy and advisory documents. This development of policy discourses is mapped from 2007 to 2018 in table 9. As this table illustrates there has been a gradual increase in the profile of heat networks in decarbonisation policy with a narrative shift from 'encouraging' heat networks and CHP (HM Government, 2007; DECC, 2009a) to defining them as 'essential' and 'cost effective'(DECC, 2013b; BEIS, 2016c). The government discourse has included both the articulation of a stronger role for heat networks in decarbonisation and recognition that growth will require the development of further policy and support measures. This has included discussion including the lack of consumer protection arrangements, variation in pricing structures and the need to develop financing, business model development and procurement processes as well as skills and common standards.

A stronger government discourse on both the need to address heat decarbonisation and the role of heat networks is mirrored by a number of reports by NGOs and other analysts which have highlighted the need for greater focus on, and clarity in, heat policy (Carbon Connect, 2014, 2015; Verco, 2014). In particular a report by Verco for WWF (2014) suggests that the Government should adopt specific targets for each low carbon heat technology and proposed a target of heat networks supplying 1m households by 2020. They suggest that this involves 32 fold increase in the deployment rate of heat networks with 25,000 homes being connected to heat networks over the past 13 years and a need for 800,000 new connections over next 15 years. The also propose similar scale increases in energy efficiency measures and heat pumps.

Carbon Connect (2014: 10), an independent, cross-party forum on sustainable energy, carried out a review of heat decarbonisation and suggested that although there is no one solution for cutting heat emissions the government should set heat as a priority area for the next 10 years and highlight heat networks as the 'biggest piece of the jigsaw missing from the puzzle of future heat for buildings'. They suggest that the Future of Heating relies too much on the RHI to drive deployment and doesn't do enough to recognise the 'mutually exclusive' nature of low carbon heat technologies, so in those areas which are targeted for heat networks there needs to be limited investment in alternative building-integrated low carbon heat technologies such as heat pumps. In their analysis of heat decarbonisation Carbon Connect (2014) suggest that there is a lack of an adequate governance structure for heat network development and advocate that more development funding, guidance on governance and ownership structures, low cost finance and regulations to require connection are required to drive growth.

There is growing recognition in policy documents that heat networks may play an important role in decarbonisation, albeit with large potential ranges reflecting the level of uncertainty regarding the penetration of individual technologies. For example the 2011 Carbon Plan suggested that between 10–38 TWh of low carbon heat would be delivered through heat networks by 2030 (DECC, 2011). The Committee on Climate Change (CCC) 4th Carbon Budget recommendations initially reflected the low end of this range with an estimate of heat network expansion to 10TWh to 2027, however in late 2013 the CCC published an update to the 4th Carbon Budget recommendations which revised heat sector estimates and increased targets for heat networks from 10TWh to 30TWh and reduced heat pumps from 160TWh to 82TWh (Committee on Climate Change, 2013). Further modelling for the Committee on Climate Change to inform the 5th Carbon Budget implies a contribution from heat networks at the top end of the Carbon Plan range at around 33TWh in 2030 with potential for cost-effective heat networks to account for 10% of heating demand in 2030 and 20% in 2050 (Committee on Climate Change, 2015b; Element Energy, 2015; Committee on Climate Change, 2016a). BEIS however indicates that heat networks may in fact supply up to 20% of heat demand by 2020 (DECC, 2013b). Whilst these policy documents and analyses vary in the decarbonisation role assigned to heat networks there is consensus that they will play a more important role in the energy system in the future and that there is a need for a new policy framework to deliver a step-change in heat network deployment.

Table 9: Heat networks policy discourses in England

Year	Policy document	Heat network reference
2007	2007 Energy White Paper (HM Government, 2007)	Contained 5 pages on decarbonising heat within a 300+ page document. One reference to heat networks was made and measures to encourage deployment of combined heat and power were highlighted. This included exemption from the Climate Change Levy, improved treatment under Phase II of the EU ETS, and planning guidance.
2008	Heat call for evidence (BERR, Defra and DCLG, 2008)	The call for evidence discussed many issues around heat network regulation, finance and consumer protection which have informed subsequent developments (such as the Heat Trust and CIBSE Code of Practice). However many of the issues discussed have not been progressed or have been established as voluntary standards.
2009	Heat and Energy Saving Strategy consultation (DECC, 2009a).	The Executive Summary to this document highlighted a ‘new focus on district heating in suitable communities, and removing barriers to their development’. Although CHP was to be ‘encouraged’ the focus in was largely on energy efficiency and building regulations. It was suggested that a ‘Summit on Community Energy and Heating’ would be convened with local government leaders to facilitate the development of heat networks and a Heat Markets Forum established to ‘ensure an appropriate market framework is in place’ however neither happened due to the 2010 election. Chapter 6 on heat networks highlighted that ‘district heating is not currently attractive in the present commercial and regulatory environment’ (DECC, 2009a: 3, 9) and recognises that heat network development is constrained by a number of regulatory, financial and commercial barriers. The document also includes a section on working with local and regional government and suggests these levels of governance will play a key role in heat decarbonisation, with the planning process and Local Area Agreements

		highlighted two routes through which local government can promote heat decarbonisation and energy efficiency (although the voluntary nature of local government action is stressed).
	2009 Transition Plan (DECC, 2009b)	This document included 2.5 pages on community scale energy in a 200+ page document. The language relating to heat networks was rather unclear referring to 'community heating' but suggesting that its role could increase from 2% to up to 14%. The Transition Plan established the LCIF grant funding programme which funded the development of several heat networks.
	The potential and costs of district heating networks: Report to DECC (Poyry Energy and Faber Maunsell, 2009)	This report highlighted a 'crucial' role for local authorities in 'enabling developers to construct low-risk district heating business models' and suggested that further initiatives were required to incentivise more active engagement across local authorities. However few of the recommendations in the report were taken forward before the 2010 election.
2010	Change in Government from Labour to Conservative-Liberal Democrat coalition	
2011	Carbon Plan (DECC, 2011)	The Carbon Plan recognises that the low carbon heat transition will be a gradual process over many decades and suggests that after 2020, heat pumps start expanding at scale, and heat networks expand form urban areas to compete with individual building-level technologies. The plan implies that these technologies would dominate in different contexts (urban and suburban/rural) but does not make reference to the mutually exclusive nature of many low carbon heat technologies[65]. The plan suggests that 21-45% of UK heat supply should be low carbon by 2030, with 83-165 TWh from building-level technologies and 10-38 TWh from heat networks. Heat networks are seen as 'viable' in up to half of heat demand but face a range of barriers relating to financing, regulation, ownership and charging structures.
	Heat Directorate created in DECC	

2012	Heat Technology Innovation Needs Assessment (TINA) (Low Carbon Innovation Coordination Group, 2012) Strategic Framework for Heat (DECC, 2012)	The TINA focused on heat pumps, heat networks and heat storage as three key heat technologies that could play a role in meeting UK and global heat demand in an emissions constrained future. It highlighted the importance of public sector activity in unlocking the development of heat technologies, both in terms of national policy certainty and local government, as publically coordinated infrastructure development is required. Suggested that heat networks 'may be an effective means of providing low carbon heat to buildings' (DECC, 2012: 34, 69, 72) and 'have the potential to play a significant role in the UK energy mix, subject to the caveats and conditions'. Local authorities are characterised as having a 'pivotal role' in enabling the development, deployment and expansion of heat networks, 'combined with private sector participation and investment', although this is largely framed as a brokerage role.
2013	Future of Heating, DECC 2013 (DECC, 2013a). Heat Network Delivery Unit (HNDU) created within DECC	The strategy document contained four core chapters on heat in industry, heat networks, heating and cooling in buildings (considering building level heating technologies and energy efficiency) and grids and infrastructure. The 'Future of Heating' document highlighted the significance of local authorities in developing heat networks. Local authorities were described as having a 'critical' and 'unique' role due to their ability to carry out energy master-planning of areas suitable for heat networks, coordinate multiple partners and broker deals, and their likely ownership of significant loads[66] (DECC, 2013a:50). HNDU was created with a budget of £9m to 2015 to support local authorities in the development of heat network feasibility studies. Creation framed as a response to the lack of skills and resources for local authorities to carry out early project development for heat network projects.
2014	HNDU second funding round:	The Minister for Energy and Climate Change Greg Barker describes heat networks as 'a

	successful applicants announced	defining part of our smarter, cleaner energy future' (DECC, 2014b).
2015	Change in Government from Conservative-Liberal Democrat coalition to Conservative majority. DECC Call for Evidence: Tackling Non-Financial Barriers to Gas CHP, 2015(DECC, 2015b). Delivering UK Energy Investment: Networks, DECC, 2015 (DECC, 2015c: 34). Heat Networks Code of Practice Heat Trust launched Spending Review (DECC, 2015d)	 This document sought evidence on whether the most significant barriers to gas CHP had been addressed and on their proposed measures[67] to address remaining barriers to CHP (DECC, 2015b). This document provided a detailed focus on the investment undertaken in networks, the challenges and opportunities on offer and a vision for what future integrated networks might look like. There is a whole chapter devoted to heat with highlights the need to rapidly decarbonise heat and an important role for heat networks. 'The portfolio of HNDU projects alone could represent between £400 million to £800 million of capital investment opportunity over the next 10 years (on an assumption of 25% to 50% of current projects coming to fruition)'. Technical code of practice and standards launched by the ADE and CIBSE in July 2015. Heat Trust independent consumer protection scheme launched by ADE and the Energy Ombudsman in November 2015. Government announces that it will allocate £300m to support the development of up to 200 heat networks over the next 5 years (DECC, 2015d).
2016	Consultation on ensuring regulation encourages innovation (DECC 2016)	Suggests that heat networks 'offer a cost-effective route to decarbonising heat in dense urban areas, with the potential to supply between 14% and 43% of total UK heat demand from buildings by 2050'…government

		is therefore 'supporting the wider deployment of heat networks as an important part of our transition to a secure and affordable low carbon future' (DECC, 2016: 10). Supports industry-led initiatives rather than formal regulation
	Heat Networks Investment Project Consultation (HNIP)	BEIS consult on the development of the HNIP.
	HNIP Consultation - Government Response, (BEIS, 2016: 4).	Launched October 2016 the government consultation response described heat networks as 'an essential part of our future clean energy infrastructure' and 'one of the most cost-effective ways of reducing carbon emissions'. Heat networks are described as benefiting multiple priorities including carbon reduction, reducing consumer bills, providing whole system benefits and acting as a 'catalyst for local growth'.
	National Infrastructure Delivery Plan 2016–2021	Energy was included as one of the core sectors in the Infrastructure Delivery Plan. This included reference to the £300m of investment support for up to 200 heat networks. Suggesting this will generate enough heat to support the equivalent of over 400,000 homes and leverage up to £2 billion of private and local capital investment (Infrastructure and Projects Authority, 2016)
2017	Clean Growth Plan	The Plan includes a commitment to 'build and extend heat networks across the country, underpinned with public funding (allocated in the Spending Review 2015) out to 2021' (HM Government, 2017). This aims to support the development a sustainable heat network market by the early to mid-2020s with further work to be undertaken in 2018-2019 examine the measures necessary to create an effective long-term market framework for the sector beyond 2020. In each of the Strategy's illustrative pathways to 2050, heat networks are projected to meet 17% of heat demand in homes and up to 24% of heat demand in commercial and public sector buildings.
	CMA Heat network market study	The market study will review how well the heat network market is working and if consumers

	launched	are getting a good deal. It is due to report in December 2018.
	BEIS Heat Networks Consumer Survey.	A survey of heat network and non-heat network consumers was carried out which concluded that overall, heat network consumers were just as satisfied with their heating systems as non-heat network consumers. Nearly three-quarters in both populations said they were 'satisfied' or 'very satisfied'. Among heat network consumers, the key drivers of satisfaction were: the reported reliability of system, the perceived fairness of price, satisfaction with the level of information provided about their system, experience of under-heating, experience of over-heating, and satisfaction with handling of complaints' (BEIS, 2017c, p. 3).
2018	ADE publish recommendations of the Heat Network Taskforce on Post-2020 Heat Network Arrangements	The taskforce recommends the introduction of a regulatory Demand Assurance framework (ADE, 2018b) which would reduce investment risk by under-writing demand risk.
	Heat Networks Investment Project (HNIP) scheme summary	The first phase of the HNIP scheduled for Autumn 2018 with the first funding decisions to be made in early 2019. The scheme will offer grants and loans to both public and private sectors in England and Wales (BEIS, 2018c).
	CMA Heat Networks market study final report	The CMA study concluded that the sector should be regulated by a public-sector body which has statutory powers to set regulation, monitor compliance, and enforce regulatory standards. The scope of regulation should include price, quality of service, transparency and minimum technical standards and the regulator should be given formal powers to introduce regulation in these areas, and to monitor and enforce compliance with regulations (Competition and Markets Authority, 2018).

The need for a range of competencies at various stages of project development means that specific parts of the project are often contracted to external consultants. However obtaining funding to carry out feasibility studies may be increasingly difficult for local authorities in the current constrained financial situation and HNDU funding has been instrumental in enabling many local authorities to progress projects (DECC, 2015e).

Heat networks are represented by two industry bodies in the UK; the UK District Energy Association (UKDEA) and the Association for Decentralised Energy (ADE). Whilst both aim to provide guidance to the industry, develop best practice and engage with government on policy development they have different membership profiles. The UKDEA has 18 full members and was founded by the heat network developer Engie and their local authority partners. Engie provides secretariat to the association. ADE is a larger network of industry and local authorities (75 heat network members) and seeks to advocate for its members across CHP, heat networks and energy services. Whilst both partly aim to support learning and skills sharing in the sector this is limited to some extent by the small size of the industry and the often multiple roles fulfilled by local authority lead personnel (Poyry Energy and Faber Maunsell, 2009). More recently, the sporadic, short-term nature of national grant programmes has limited the growth of district heat skills and supply chains in the UK (Poyry Energy and Faber Maunsell, 2009).

In addition, heat currently operates under a comparatively (to electricity) weak regulatory landscape. There is no specific heat regulator with regulation relating to heat generally focussing on generating fuels such as natural gas. Regulatory requirements that do relate to heat supply generally fall under consumer protection rules (Bolton & Foxon, 2013b; Hawkey, 2012). However the industry and Government has recognised the need for further consumer protection requirements through the development of the Heat Trust but has not made a commitment to formally regulate the market.

This increasing focus on the future regulation of heat networks included a CMA market study which determined that the sector should be regulated by a public-sector body which has statutory powers to set regulation, monitor compliance, and enforce regulatory standards (Competition and Markets Authority, 2018). In late 2018 the Government issued a report which welcomed the CMA's findings, set out their support for sector regulation and consulted on high level principles for future market arrangements (UK government, 2018). A more detailed consultation and policy options are expected late in 2019.

The report also emphasised that Government policy is seeking to develop a more supportive framework for heat networks through offering developmental support through the HNDU and investment support through the HNIP. However longer-term governance and regulatory structures remain unclear. Hawkey and Webb (2012: 19) suggest that current governance is ‘governance under uncertainty’ as each project largely develops its own governance approach. They argue that this uncertain governance is unlikely to result in fast expansion of heat networks in the UK due to persistent risks, uncertainty and costs. Instead ad-hoc local innovation is likely to continue with local authorities taking an important role in coordination and risk reduction.

More recently various policy analysts and think-tanks have supported this assertion and suggested that distributed technologies challenge the ‘logic’ of the UK energy system (Platt et al., 2014: 3; Julian, 2014). The IPPR’s report on city energy (Platt et al., 2014: 5), although largely focussed on the changes needed in the electricity market, cites a ‘prevailing bias’ across energy regulation and policy towards a large-scale utility business model which does not facilitate alternative models (such as heat networks and CHP) which might be more appropriate at a small to medium scale. It can also be argued that heat networks have not been supported by the broader neo-liberal paradigm that has dominated governance in several countries (notably the UK) which has framed the priorities of energy policy as about increasing efficiency and reducing state involvement. Both Kuzemko (2013) and Meadowcroft (2009: 492) suggest that this context influences how institutions develop and the policy options open to them, resulting in a focus on technologies that ‘slot easily into the existing large and centralised system’ and a lack of trust in the ability of government, including local government, to manage sectors of the economy such as energy.

5.4 Problem definition and the role of heat networks

This section discusses how problem definition discourses have been utilised in relation to heat networks in England, as well as how debate of policy options has developed. Shaping the definition of a problem and its possible solutions is widely acknowledged as a technique utilised by actors to shape policy responses in the discursive institutionalist literature (Carstensen and Schmidt, 2016)[68]. This sees problem definition, and the selection of solutions, as an expression of different ideas, interests and power relations rather than as a consensual process based on rational arguments (Habermas, 1987). A number of key problem definition storylines were evident in the shaping of the discursive space for heat networks in England, these storylines can be summarised as ‘heat policy neglect’, ‘limitations of an all-electric future’, ‘delivering multiple priorities’ and ‘barriers to heat networks’, as discussed below.

5.4.1 ‘Heat policy neglect’ and ‘limitations of an all-electric future’

As discussed in chapter 2 there has been a gradual recognition across policy and industry literature of the need to focus on the decarbonisation of heat in order to meet carbon reduction targets. This identification of a policy problem in the form of the slow rate of heat decarbonisation has been an important wider context for an increased focus on the role of heat networks and was highlighted consistently by heat network actors across the local, national and international scale (interviews 3-NGO, 23-C, 27-G, 17-LA, 29-TA; International Energy Agency, 2004; DECC, 2012; Carbon Connect, 2014). Additionally this recognition of the relative neglect of heat decarbonisation policy was aligned, by both heat network and wider heat policy actors, with a second storyline relating to the limitations of an all-electric future as a route to decarbonise heat. This marks a departure from the focus in the late 2000’s on the electrification of heat, based on growing evidence that very extensive electrification of heating would require significant reinforcement of electricity networks and present problems in terms of system balancing during peak demand (Eyre and Baruah, 2014; Energy and Climate Change Committee, 2016).

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[68] As well as in policy studies literature more widely (such as Kingdon, 1995; Voß and Bornemann, 2011; Béland, 2017).

Until the publication of The Future of Heating strategy document in 2012 (DECC, 2012) Government policy[69] was largely focussed on electricity decarbonisation with the Carbon Plan (DECC, 2011) suggesting that the focus should be on decarbonising electricity generation, through renewables and gas, until the 2020s. Likewise the Committee on Climate Change's 4th carbon budget review suggested that electrification would dominate heat decarbonisation in residential and commercial properties but highlighted a 'limited role for district heating, reflecting uncertainties around technical and economic aspects of this option, with the possibility of deeper penetration as uncertainties are resolved' (Committee on Climate Change, 2010, p. 24). More recently the Committee on Climate Change has highlighted the slow rate of heat decarbonisation and suggested that the abatement potential of heat pumps may be limited by low take up, necessitating greater penetration of alternative low carbon heating systems such as heat networks (Committee on Climate Change, 2013).

Interviews across all categories emphasised how growing recognition of the difficulties associated with the large scale electrification of heating, both from the perspective of increased electricity demand and the practical implications of installing heat pumps in existing low efficiency housing[70], was leading to more focus on heat networks as an alternative route to decarbonising heat, particularly in urban settings. As one interviewee put it 'as there's been more research into scenarios there's been a realisation that yes heat networks are expensive but electrification is also expensive so heat networks now get a fair crack too' (interview 26-NGO).

Focus on the electrification of heat in the late 2000s and early 2010s was linked by interviewees (interviews 3-NGO, 5-NGO, 13-C, 14-C, 27-G, 28-A, 29-TA) to the appointment of David MacKay as Chief Scientific Advisor within DECC in 2009. MacKay was appointed following the publication of an influential book, 'Sustainable Energy - without the hot air', in which he describes CHP as 'a bad

[69] Such as such the 2007 Energy White Paper (HM Government, 2007) and the Carbon Plan (DECC, 2011).
[70] Heat pumps are most efficient when producing low temperature heat in well insulated properties, ideally through underfloor heating systems or warm air heating rather than radiator-based systems (Energy Saving Trust, 2017).

idea, because there's a better technology for heating, called heat pumps' (Mackay, 2009, p. 144). MacKay was Chief Scientific Advisor until October 2014 and although the increase in government focus on heat networks from 2010 onwards largely happened while MacKay was still in post interviewees suggested that MacKay's well known 'dislike' for heat networks and CHP, together with a lack of support from senior management within BEIS, had created a culture where heat networks were marginalised. As one interview suggest 'there in the heart of DECC was an individual that had a very set view about how Britain could decarbonise which was to move to an all-electric future and the industry basically lost 4 years while MacKay was there' (interview 27-G).

MacKay was publically more supportive of heat networks in the Future of Heating document where he suggested that CHP can be viewed as 'virtual heat pumps' (DECC, 2012, p. 8) and interviewees suggested that BEIS have now 'realised that in all these pathways district heating comes up as an investment you won't regret and I've heard really interesting arguments in favour of district heating recently where it is essential to the electrification of heat' (interview 3-NGO). However the shift to a broader acceptance that heat networks may play a role in decarbonisation was framed by interviewees as happening *despite* an ongoing lack of support from senior levels within BEIS and these changes were attributed as resulting from greater analysis of the implications of different heat decarbonisation pathways and recognition that a portfolio of technologies would be required (interviews 4-G, 16-LA). This illustrates how heat network advocates have sought to emphasise the cognitive appeal of heat networks framing them as a logical technology once the limitations of electrifying heat are acknowledged, particularly due to their ability to integrate multiple heat sources including the use of gas in the short to medium term. One interviewee suggested that;

> 'people started to move away from a sort of single silver bullet idea and began to think sensibly about that you actually need to look at each individual area and think about what the best solutions are for that particular heat demand profile but also in addition the sources

> of heat supply that are in that area. So the debate just became a bit more sophisticated I think and the size of the challenge was clearly articulated' (interview 4-G).

Both the storylines of 'heat policy neglect' and 'limitations of an all-electric future' appear to have been helpful in positioning heat networks within a broader policy focus on heat due to the interpretive flexibility of these discourses, where advocates of different policy approaches or technologies can all adopt the same storyline(s) in order to promote their objectives although they may promote different solutions to the problem. For example, storylines of 'heat policy neglect' and 'alternatives to an all-electric future' can be utilised by interests such as biomass companies, hydrogen injection companies and heat network companies but the policy solutions they seek to promote are likely to be very different. This adoption of twinned storylines which exhibit interpretive flexibility fits well with the policy approach of the UK Government which tends to make broad policy statements (such as the need for greater focus on the decarbonisation of heat) in the context of a philosophy of not 'picking winners'. This leads to extensive policy debate and positioning by various interests in the relevant sector in order to secure governmental support for their priorities.

In terms of the role of heat networks in addressing these policy problems, both national and local interviewees highlighted that there had been increasing political interest in heat networks over the last 5-8 years, although this has taken place from a very low base. This was evident in policy documentation with heat networks occupying a more prominent position in recent years (see the chronology of heat network policy in chapter 2 and DECC, 2012, 2013a; HNDU, 2015). Given that a range of interests utilise the storylines of 'heat policy neglect' and 'limitations of an all-electric future' interviewees suggested that there were a number of additional factors which had driven this increased focus on heat networks. Partly this was seen as a result of ongoing debate regarding the options to decarbonise heat with heat networks framed as future proofed infrastructure due their ability to incorporate different generating technologies over time. This was reflected in the Future of Heating (DECC, 2013b) which highlighted their benefits of heat networks in terms of generation flexibility.

Additionally recognition of the potential role of heat networks in decarbonising heat also resonates with a number of other energy policy priorities including greater consideration of the future role of gas[71] (see DECC, 2013b; Carbon Connect, 2015), unlocking finance for infrastructure investment (HM Treasury, 2013; Green Investment Bank, 2015), and the need to integrate heat and electricity and maximise system flexibility (interviews 5-NGO, 17-LA). Heat networks were also seen by a number of interviewees as receiving more attention due to the limited number of other options available to decarbonise heat in urban areas which have high heat demand density.

In terms of differences between problem identification at the local and national level, although the storyline of heat policy neglect was present in local discourses it was less pronounced and local actors tended to frame heat network development in relation to wider energy system priorities such as heat and electricity integration and flexibility, as an extension of existing efficiency programmes and as part of wider social and economic priorities (interviews 1-NGO, 8-LA, 14-C, 17-LA, 25LA). Both Sheffield and Birmingham have been developing heat networks for over 15 years and non-climate drivers were significant objectives in initial development. All three case studies identified climate change as a central driver for current network development and framed the development of heat networks as the natural progression of wider climate change objectives. They also highlighted the long lead in time for heat network projects with current projects in each of the three cities generally in development prior to central government's increased focus on heat networks.

5.4.2 Delivering multiple priorities

As discussed, heat networks were identified as potentially delivering multiple priorities by both national and local actors. Although there was a degree of consensus regarding the range of issues that heat networks could address there were a number of opportunities that were highlighted more strongly at a local level. In particular city actors placed greater focus on the potential for heat

[71] Given that most heat networks in England are currently based on gas CHP.

networks to deliver non-climate objectives, such as addressing fuel poverty and supporting regeneration (interviews 11-MU, 16-LA, 19-LA, 23-C). An interviewee who works with multiple local authorities on heat networks suggested that 'the people that are driving this, in the local authorities, are just not motivated by the energy, it's the big picture. It's about climate change, it's about fuel poverty, it's about economic regeneration, it's about resilience of infrastructure in those cities' (interview 14-C). Other studies have established that local authorities often pursue heat networks to deliver a range of complex social, environmental and economic objectives which go 'beyond the traditional economic drivers of market actors' (such as Bale *et al.*, 2014, p. 66; Hawkey and Webb, 2014) and it is not uncommon for local projects to develop based on 'acceptance that the primary return on investment would be in relation to local well-being and economic benefit, rather than the rate of return on finance'[72] (Webb, 2015, p. 270).

Interviews and policy documents suggest that national discourses are beginning to refer to the wider benefits of heat networks with, for example, the Future of Heating strategy document (DECC, 2012, p. 59) recognising that heat networks can be integrated with 'local authority plans for urban growth and regeneration aimed at tackling social deprivation and environmental issues such as air quality'. However national debate tends to go into little further detail regarding the integration or valuation of these multiple objectives. For example the aims of the Heat Network Investment Project funding is to increase the volume of heat networks built, deliver carbon savings and help to develop a self-sustaining heat network market. Although reference is made to ensuring networks operate with no customer detriment in comparison with alternatives this focusses on ensuring cost comparisons are made between heat networks and alternative heating options. Guidance on assessing wider social costs and benefits is limited with the HNIP application guidance suggesting that an assessment of social net present value (NPV) should take place in line with Treasury Green Book guidance. In theory social NPV assessments take into account all costs and benefits to society, however the guidance only identifies carbon emission

[72] Webb is referring here specifically to the development of Aberdeen Heat and Power.

costs and air quality costs as elements of the social NPV calculus (as well as capital, operational and maintenance costs) so does not include consideration of potential fuel poverty or regeneration benefits (BEIS, 2016d).

In comparison at the sub-national level both local authorities and other actors such as housing associations and NGOs increasingly recognise that heat networks can deliver complex multiple objectives and that delivering these various objectives is likely to involve contestation and negotiation between multiple public, quasi-public and private actors (Hansen and Coenen, 2015, interviews 16-LA, 17-LA, 23-C). This was evident in the complex actor networks in the case study cities where the local authorities were seen by both public sector and industry actors as the agency with responsibility for negotiating competing interests in heat network development and balancing social, environmental and financial objectives. For example interviewees in Sheffield suggested that the City Council acts to coordinate a network of public and private organisations around a range of priorities such as carbon emissions, waste management priorities, local industrial strategy and fuel poverty. This has not been dispute free and the local authority’s strategy of working with commercial partners to deliver heat networks adds complexity to the strategic planning work it is attempting to develop (interviews 8-LA, 23-C). This has included difficulty in oversizing plant to allow for new development or developing new pipelines when investment decisions are made by commercial interests, particularly in relation to Veolia whose primarily interest relates to the Energy from Waste (EfW) plant.

Bale *et al.* (2014) highlight similar difficulties in planning for long-term heat network growth under the current UK market based model as oversizing networks to allow for future growth, what they term ‘passive provision’, is influenced by a number of uncertainties relating to future network scale, heat sources, customers and how different outcomes (such as social, economic and environmental) will be valued. The difficulty in delivering passive provision in order to support long-term objectives was recognised across all the city cases but in a variety of ways. In Bristol there was recognition that there was a need to take a ‘strategic approach, but at the same time we need to recognise that if we say you ought to put in a great big pipe here, it's probably not going to happen so we need to think of different ways of being able to deliver that same future capability' (interview 23-C). To partly avoid the need to build in extensive passive provision the council is developing a number of small networks with the potential to expand and connect in future and suggested that the retention of ownership was helping them to balance multiple objectives as non-financial objectives could be better integrated (see section 5.5.3 for more discussion of ownership). Birmingham also recognised the complexity of negotiating multiple priorities, suggesting that the structure of BDEC did not always support the integration of a range of objective; 'The BDEC scheme is owned and operated by Cofely which removes the risk from the Council, but also the potential benefit – both to Birmingham City Council and to some extent, consumers, if Birmingham City Council would be willing to reduce tariffs to ensure connections for the fuel poor communities, for example' (interview 25-LA).

This evidence of heat networks connecting multiple local actors with complex objectives aligns with Webb's (2015, p. 270) case study of Aberdeen Heat and Power which suggests that the heat networks can act as a 'a hinge connecting multiple local interest' where 'local knowledge about non-monetarized costs and organizational structures' is emphasised over traditional techno-economic rationality. While the cases studied in this research all suggested that values outside of financial rate of return can be significant drivers for heat network development all the cases also demonstrated the difficulty in aligning complex priorities, particularly when different actors may have different priorities or be seeking to realise their objectives over different timescale. In Bristol this has included complexity in aligning investment timescales of the Council, University Hospital Bristol Foundation Trust and the University of Bristol. Additionally, although the council is evaluating ownership and operation models on a network by network basis they suggest that delivering these networks with a private-sector partner via an Energy Services Company is not the preferred approach due to the loss of strategic control and the perceived increase in difficulty in delivering multiple objectives. In Birmingham, although the BDEC model is widely seen as successful it is also framed as resulting in difficulty in addressing multiple priorities such as carbon reduction and fuel poverty as these priorities are seen as ‘having high costs and low returns’ (interviews 17, 25; Webb and Hawkey, 2012, p. 16).

Similarly, in Sheffield multiple priorities were highlighted as driving heat network development, however financial objectives were more strongly emphasised in this case. This involved heat networks being linked to local economic growth (via the ‘Made in Sheffield’ storyline) and the council’s financial position. Initially, in 2001, the council sold the Bernards Road incinerator to Veolia partly as it could not afford to upgrade the plant to meet air quality requirements. More recently the council have initiated a review of the Veolia contract, which was not due to expire until 2036, in order to try to reduce the cost of the £1.3 billion contract (Lets Recycle, 2017). The council is also considering setting up a municipal energy supply company and both the future of the Veolia contract and the potential development of a municipal utility were linked to the financial situation of the authority and the need to develop projects that simultaneously deliver on financial, social and environmental benefits (interviews 8-LA, 23-C).

Navigating these multiple priorities and interests is a complex role for local authorities and, although HNDU support can include detailed project development and some stages of commercialisation the focus is largely on funding consultancy support to carry out mapping, master planning, feasibility studies and technical project development. Although all these stages are clearly essential to the successful development of heat network projects they emphasise techno-economic rationalities rather than the challenges relating to governing complex, multi- actor and multi-objective projects. In particular interviewees emphasised the lack of skills within local authorities to govern the development of energy infrastructures where the growth of the network, long-term customer base and future generation plant may all be uncertain. The issue of skills is returned to in the next section (5.4.3).

Notwithstanding these differences between the local and national problem framings, heat network storylines were being aligned by all actors with a range of other storylines (heat policy neglect, alternatives to an all-electric future, future role of gas, integration of heat and electricity). This demonstrates how actors at multiple scales are constructing heat networks as part of the 'solution' to a range of problems in order to develop support for increased policy intervention. Whilst there was substantial consensus across policy documentation and interviewees relating to the problems that heat networks could help to address, there was significantly more variation in identification of the most significant barriers and policy priorities, as discussed in the next section.

5.4.3 Barriers to heat networks

A generalised storyline of heat networks facing multiple barriers was adopted by interviewees across all actors groups and was strongly represented in government and industry documents (such as DECC, 2012, 2013a; BRE, University of Edinburgh and Centre for Sustainable Energy, 2013; Association of Decentralised Energy, 2015; Frontier Economics, 2015). This included the recognition of a number of shared high level barriers as discussed in section 2.6. These common barriers and can be summarised as (1) financial, (2) governance and regulatory, (3) complexity and the locally bespoke nature of projects, (4) energy market design, rules and processes and, (5) public perceptions. Despite general consensus on these broad categories across interviewees and studies (such as Russell, 1986; Hawkey, 2009; DECC, 2012; BRE, University of Edinburgh and Centre for Sustainable Energy, 2013; Bolton and Foxon, 2014; Frontier Economics, 2015) closer examination of the prominence assigned to the various detailed barriers reveals a range of different positions in relation to how heat networks should be best promoted. This demonstrates how simple overarching storylines, such as heat networks facing multiple barriers, can be widely adopted in order to raise a policy area up the agenda and create a rationale for action. However, this simplification of storylines can also conceal differing views on the most significant barriers and dispute regarding priorities for action.

In this respect government discourses tended to focus on financial and consumer barriers whereas other organisations such as the Committee on Climate Change (2015) and Frontier Economics (2015) also emphasised the importance of policy uncertainty and policy conflicts in slowing the growth of heat networks. The impact of policy certainty and policy conflicts was also highlighted by industry, local authorities, consultant and NGOs interviewees (interviews 2-C, 17-LA, 22-DHU, 23-C) with one interviewee suggesting that 'the biggest barrier to heat networks in this country is the policy because its non-comital, short-term, non-existent' (interview 13-C).

Heat networks may be particularly susceptible to policy uncertainty due to the capital intensive and long-lived nature of the infrastructure (Frontier Economics, 2015) and interviewees described the policy environment for heat networks as based on short term support which tends to be extended on a year by year basis. For example the initial HNDU funding was allocated for two years from 2013 to 2015 and has since been extended several times. The HNIP project aims to allocate capital funding between 2017 and 2021 and some organisations have already called for this funding to be extended to 2030 due to the long development timescales of heat network projects (Emden, Aldridge and Orme, 2017). Prior to the launch of the HNIP the money allocated to the HNDU was described by interviewees as 'pennies really' (interview 29-TA) and interviewees also identified broader uncertainties within government which had slowed progress on heat networks, including General Elections in 2010 and 2015, the 2015 spending review and the restructuring of DECC into BEIS in 2016 (interviews 9-NGO, 26-NGO, 28-A).

In addition to policy uncertainty a number of policy conflicts or changes were identified by interviewees as undermining progress on heat networks. This included the intermittent nature of grant support (such as CSEP and HNDU), the scrapping of the Zero Carbon Homes policy, the structure of the RHI, changes to Renewables Obligation biomass grandfathering which impacted on some biomass CHP networks and barriers to CHP participating in the Capacity Market (ADE, 2017b; interviews 23-C, 28-A). One local authority interviewee summarised it as 'We just want some clarity about what this government wants going forward and not chopping and changing and cutting this then that'. They also highlighted that both the structure and the risk of changes to the RHI were a barrier to heat network development; 'if we're connecting some buildings now on the biomass network we can put in an RHI application but if in 12 months we say we want to connect X or Y we might have to reapply and if the RHI is dropped it affects the whole scheme so there's no point in doing it. The RHI needs to change if it's going to reflect how heat networks expand gradually. We don't even know what's going to happen to the RHI next year' (interview 17-LA).

An additional significant difference in the framing of barriers relates to financing heat networks. There was a strong narrative in government and industry discourses that financial barriers were the most significant barriers to heat network development. While sub-national interviewees did not dispute that financial barriers were very significant in developing heat networks these interviewees also stressed the importance of a lack of policy framework and the need to develop skills (interviews 2-C, 3-NGO, 8-LA, 17-LA, 23-C). National actors tended not to emphasis the scale of the skills that are likely to need to be developed within local networks, and particularly within local authorities, to facilitate heat network development. As discussed later in this chapter (section 5.5.2), although there is broad consensus that local government will need to play a central role in heat network development, emphasis tends to be put on business models being locally contingent according to specific priorities, historical contexts and actor networks. This backgrounds the commonality that local authorities are likely to be key governing organisations in all business models with the requirement for a number of core competencies to be developed in relation to negotiating with complex actor networks and managing long-term contracts.

The need to develop new skill sets within the council was particularly raised in Bristol. It took several years to develop the in-house skills required and there was considerable reliance on consultancy support during this time. Additionally the complexity of actor networks, both within the council and externally, required a great deal of negotiation and relationship management, particularly as organisational priorities and/or timescales do not always align.

Although Birmingham and Sheffield both have a longer history of heat network development and more established skills sets within key local organisations, internal capacity for project management was cited as 'one of the main barriers for local authorities in developing new networks...Whilst adequate levels of funding support is being made available to local authorities, in a time of further cuts and pressures it is becoming increasingly difficult to see how some of the schemes will come to fruition. This isn't necessarily a DECC problem, but a central government issue. There is no mandated role for local authorities to support the government in its delivery of energy policy' (interview 25-LA).

Sub-national actors also acknowledged that local authorities are approaching heat network projects in very different ways with differing competencies to manage projects well. For example local authorities which are integrating heat networks into broader priorities relating to economic development, regeneration, as well as carbon reduction, were described as having 'much clearer political support' with heat networks embedded into long-term plans (interview 19-LA).

5.5 Established and emerging discourses

A number of established discourses were important in shaping the development of approaches to heat networks. Equally emerging storylines, referred to as 'storylines in the making' by Bosman *et al.* (2014, p. 48), can put pressure on dominant storylines and can 'point towards future developments'. This section explores the interplay between significant established and emerging discourses and how they have interacted with the direction of policy.

5.5.1 Financing

Within government and industry debates accessing third party finance was a significant theme based on evidence that heat networks are currently generally financed on balance sheet, either by a local authority or a commercial network developer, with limited instances of third party project finance. Government interviewees suggested that the sector was experiencing a significant increase in interest from a range of third party investors including insurance, construction and energy companies (interviews 4-G, 21-C). Access to these sources of funding was described as a route to enabling more rapid delivery of projects as local government sources of finance were portrayed as limited. This theme of unlocking finance was also promoted by industry, with the ADE suggesting that 'all other UK energy network infrastructure has a clear policy framework that has been successful at securing investment from institutional investors keeping down the costs' (ADE, 2016, p. 2).

While the majority of interviewees accentuated the importance of access to finance a minority of interviewees – representing NGOs, local authorities and community heat networks (interviews 2-C, 5-NGO, 13-C, 14-C) – suggested that the focus on reducing investment costs and attracting commercial finance was incorrect as there were alternative sources of low cost capital. As one interviewee put it:

> 'there's this conception that it's going to be done through the private sector and I don't think that it will…the Infrastructure Investment report, it talks about the Green Investment Bank yet again but then it actually says that some local authorities may wish to actually own these entities in which case they can go to the Public Loans Board so they're beginning to concede at Whitehall level that there may be possible other options for doing it' (interview 14-C).

These actors suggested that local authorities can source large amounts of funding for capital projects from the Public Loans Work Board without central government consent, provided they can afford the borrowing costs[73]. However, as identified by several interviewees, this source of capital is highly competed as local authorities have a wide range of other projects competing to access this funding. As one interviewee suggested, the issue for local authorities is 'prioritising it [heat networks] and believing that it might be a worthwhile income stream for them' (interview 4-G). This frames the challenge as partly about prioritising the benefits of heat networks locally rather than necessarily about attracting low cost international finance.

[73] As highlighted in chapter 2 the PWLB issues loans to local authorities for capital projects, drawn from the HM Government's main borrowing and lending account, the National Loans Fund. PWLB interest rates are at historic lows and in 2016/17 the PWLB advanced 622 new loans to local authorities with a value of £3,634 million (UK Debt Management Office, 2017).

While the Sheffield and Birmingham cases had a history of securing private investment in heat networks both highlighted that they were also considering local authority investment in future growth. Similarly in Bristol there was a focus on public investment in heat networks with the authority indicating that ‘at the moment while we’ve got opportunities like Prudential Borrowing, quite low interest rates, we’re quite happy to have lower rates of return’ (interview 17-LA).

Emerging evidence from the HNIP pilot phase indicates that, of nine projects supported, seven were accessing public sector sources of finance, one was a public-private partnership and one was financed by the private sector. Clearly this is a small sample size but suggests that local authorities are increasingly exploring utilising public financing routes rather than private finance to develop heat networks (BEIS, 2017d). Similarly a range of (non-industry and central government) interviewees suggested that utilising public sector finance may be desirable as ‘the big energy companies, Cofely, E-On people like that, are seeking a hurdle rate of 12% and above whereas at the other end we’ve got municipal energy companies where’re you’re doing it through the Public Works Loan Board where they can borrow capital at 3.5% so they can actually do it at around 6 or 7%’ (interview 21-C). Additionally some more radical voices in the interviewees suggested that the focus should move on from accessing capital to addressing other barriers to heat networks and that public money should be used to finance heat networks on the understanding that a ‘third energy network’ was being constructed and should therefore be publically funded in line with other energy networks in the UK (interviews 2-C, 3-NGO). This storyline emphasises that the initial development of other energy networks (gas and electricity transmission and distribution) were funded by the public purse and challenges the narrative adopted by ADE that all other UK energy network infrastructure has been ‘successful at securing investment from institutional investors’ (ADE, 2016, p. 2).

Whilst this financing storyline was utilised across a range of organisations to highlight how the different properties of heat networks resulted in a higher cost of capital, a range of other actors suggested that there was insufficient discussion of how addressing non-financial barriers could also reduce project risk and the cost of capital. In fact there are multiple ways in which the risks relating to heat network development could be reduced including paying a tariff based incentive to heat networks (or other methods of underwriting project risk such as loan guarantees), the development of consumer protection measures such as formal price oversight and licensing, and the provision of dedicated local heat zones within which connection to heat networks can be mandated. Several of these measures were suggested by the Committee on Climate Change in a report on enabling deployment of heat networks (Element Energy, 2015) and are currently under consideration by the Scottish Government in their consultation on the regulation of district heating (Scottish Government, 2017). Indeed recent government and industry initiatives such as the HNDU, the HNIP, the Heat Trust and the Heat Networks Code of Practice all aim to ultimately reduce the cost of capital as more standardised approaches to project development, customer service and technical standards increases investor confidence.

5.5.2 The role of local authorities

This section explores how an emerging storyline in relation to the role of local authorities is presented by different actors and acts as a site of argumentation and contestation. In particular it discusses the consensus of an important role for local government in brokering local actor networks and the more contested narratives relating to local authority ownership and operation of heat networks.

5.5.2.1 A changing local government agenda

As discussed in section 5.4.2.2 a theme of local authorities taking a central role in heat networks was evident. Local authority interviewees, and those working with local authorities, connected this to a range of broader changes to the local governance environment. Firstly, a dramatic reduction in the local government funding settlement was framed as driving some to consider alternative routes to raising revenue, albeit in the context of heat network returns tending to be relatively low and long-term. Several interviewees described a need for a more commercial approach due to reduced local authority budgets (interview 17-LA, 15-NGO, 25-LA, 27-G) with one interviewee suggesting that;

> 'there does seem to have been, particularly since the downturn in the last 5 years, a much more commercially focussed approach – I meet many more people in local authorities who now actually understand to some extent how business works and have a view of how they could bring a business plan together to deliver something which is going to generate some revenue' (interview 23-C).

Secondly, as discussed in 2.5.1, the comparatively limited powers of local authorities in the UK have been extended somewhat with a number of powers[74] introduced or amended to allow local authorities to undertake activities outside of their statutory responsibilities, raise revenue and carry out commercial trading through arms-length companies (Sandford, 2014; Communities and Local Government, 2009). These new powers make it easier for local authorities to engage directly in energy generation and supply activities, although this broader decentralisation trend has been contested with the English devolution process[75] described as opaque with decision making situated with central government (Randall and Casebourne, 2016). Likewise some interviewees suggested that the relaxation of local government borrowing rules was 'unleashing them [local authorities] a little bit' (interview 23-C) whereas others were sceptical regarding the extent of local devolution suggesting that 'it hasn't happened, the opposite has happened' (interview 28-A). There was also a perspective that although local authorities now had more freedoms and flexibilities from central government they had not generally had skills and competencies in energy since the 1950's so were finding it difficult to re-engage with the system. This was at a practical level in terms of having suitably qualified and experienced people but also in relation to legal and financial personnel being uncomfortable pursuing energy infrastructure projects due to a lack of professional norms or experience.

[74] Notably the Wellbeing Power in the 2000 Local Government Act and the General Power of Competence provided for in the Localism Act 2011.
[75] Provided for in the Cities and Local Government Devolution Act 2016.

Thirdly, local authorities linked their involvement with heat networks with a desire (and need) to deliver on complex multiple priorities with local authority heat network advocates described as ‘not just motivated by energy, it’s the big picture, it’s about climate change, it’s about fuel poverty, it’s about economic regeneration, it’s about resilience of infrastructure in those cities’ (interview 14-C). Finally, local interviewees alluded to a re-examination of the relationship between the State and private sector following the 2008 global recession amidst concerns that the private sector has failed to reduce costs and increase efficiency (Wollmann, 2012). Local government and industry representative interviewees both referred to a perceived failure of the current energy incumbents to deliver a low carbon, affordable energy system and one interviewees suggested it was;

> ‘about challenging how our society is organised…where people are actually controlling what the energy company does and saying we want it to take a certain set of renewables, we want it to send a pipeline in this direction even though it doesn’t necessarily make commercial sense at this particular moment but we believe it will do in the future’ (interview 14-C).

This included Bristol’s municipal supply company suggesting that they offer a ‘simple, fair and transparent alternative to the Big Six, in a market that is often perceived as broken and unfair to loyal customers’, emphasising that they are a ‘force for social good…championing social equality, local renewables and stronger communities’ (Bristol Energy, 2017).

5.4.2.2 Enabling or ensuring?

Notwithstanding the changing local government role identified by many local actors, an established consensus storyline was evident relating to an important brokerage role for local authorities. Government policy documentation and interviews with civil servants and industry emphasised this brokerage role and framed this in terms of setting local planning requirements, ownership of key anchor loads and the ability of local authorities to coordinate a range of public and private sector actors at the local level (interviews 12-TA, 14-C; DECC, 2009a, 2013a, 2015c; Combined Heat and Power Association, 2013; Ricardo Energy and Environment, 2015). While this brokerage role doesn't preclude local authorities taking a more central role in heat network development, operation or ownership it does imply their role is limited to getting the right people working together to enable commercial organisations to deliver projects. At a national level heat networks were framed as essentially apolitical undertakings with decisions based on techno-economic feasibility and the risk appetite of partners. In this context local governments are seen as important facilitators, but ownership structures are to be determined by traditional cost-benefit analyses.

This storyline resonates well with a wider institutional norm of an 'enabling' role for local government which frames contemporary local governance as setting the parameters for action but not being directly involved in delivery (see chapter 2). This widespread use of a 'local authorities as brokers' storyline by industry and policymakers demonstrates how discourses can be used to position actors and establish a conception of the 'right' role for certain actors. However the ambiguity related to the language used, referring to the role of local authorities as 'brokers', 'crucial' and 'central' also allows different actors to interpret their own understanding of the appropriate role for local government. This interpretive flexibility can be helpful for discourse success as actors can fit the storyline to their own interests (Schmidt, 2006).

In contrast to this equivocal role identified for local authorities the focus of recent policy, in the shape of the HNDU and HNIP, has placed strong emphasis on the role of local authorities. Whilst initially these policies appear to centre the role of local government in the development and operation of heat networks closer analysis reveals ongoing flexibility in the characterisation of their role. Although local authorities are exclusively eligible to apply for support through the HNDU a key objective of the funding is to develop 'investment ready' projects and attract commercial partners. Additionally although the initial round of HNIP funding was focussed on local authorities and other public sector organisations as the conduits for funding it was possible for monies to be on-invested in private sector organisations (BEIS, 2016d). HNDU support does include advice on assessing ownership and operation options, including local government ownership, however wider government and policy discourses frame the operation of energy networks as not a role for local government, as discussed in the next section. This suggests that an 'enabling' role for local governments is still embedded in central government thinking in relation to heat networks, despite recognition of their important coordination role.

Local actors presented a more consistently central role for local government suggesting that 'local authorities are the lynchpin for developing heat networks' (interview 17-LA). This resulted in extensive local discussion of the relative benefits of different commercial and governance arrangements which was largely absent from central government discourses. For example Bristol, Sheffield and Birmingham are all exploring the opportunities and risks of different ownership and operation models despite each of the cities having very different experiences, and types, of heat networks. The importance of local authority involvement in order to retain a degree of local control and to deliver complex, multiple objectives was however emphasised across the cases, despite their different approaches with an interviewee who had worked with all three cities suggesting that

> 'a lot of people [local authorities] are saying actually we want to be in control of this because then we get some kind of grip on getting the project to go forward...So the control thing for local authorities does seem to be the one common thread' (interview 23-C).

Despite this wide recognition that local authorities play an important role in negotiating multiple objectives a number of tensions were also identified. For instance while 'councils have to really take a leadership role because they're the only organisations that really have got that wider view whether that's regeneration, economic development, fuel poverty' (interview 19-LA) they will have varying capabilities to achieve these multiple outcomes. Smaller authorities are likely to find it difficult to resource and develop the competencies required to effectively deliver complex heat network projects or to accept the higher levels of risk associated with taking a more central role in ownership and operation (interviews 15-NGO, 25-LA, 28-A). As one interview suggested ‘some authorities don’t have that big thinking about what heat networks can offer them and that certainly goes for a lot of the smaller authorities that haven’t got the capacity and where an investment decision for a few million pound heat network is quite a big deal’ (interview 17-LA).

Similarly the history, politics, and range of other priorities in each local authority are likely play an important role in shaping local approaches. In Sheffield the history of a strong industrial sector and ongoing variation in the financial position of the local authority had resulted in an emphasis on the economic benefits of developing heat networks. There was also considerable familiarity of working with multiple partners and an openness to a range of delivery models simultaneously being used in the city, including potentially a revival of public ownership.

In Birmingham the successes of the BDEC arrangement in delivering a large and complex network were acknowledged. However this arrangement was also seen as limiting the ambition of the local authority due to the difficulty in incorporating fuel poverty objectives. Like Sheffield this resulted in a view that it was likely that networks would be operated under a range of models in the city but that the local authority potentially had a more significant role to play in the future.

Bristol developed their heat network projects during a particularly ambitious period in the local authority in relation to climate leadership[76] and the lack of established governance structures for heat network development appears to have enabled the city to have greater debate regarding the role of the local authority. In particular the development of a municipal utility was influential in promoting the authority to pursue council ownership of networks. The development of the municipal utility was driven by both frustration in the city at the difficulty in working with mainstream energy suppliers and a desire to integrate council activity on fuel poverty and sustainable energy.

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[76] Including being awarded European Green Capital, securing ELENA funding and attending the Paris climate change negotiations in 2015.

5.5.3 Ownership and (re)municipalisation

Interlinked with the ‘role of local government’ storyline an emerging theme regarding the ‘(re)municipalisation’ of energy infrastructure and services was evident from a range of sources. As commonly the case for emerging storylines this narrative was relatively unstructured compared to the coherence of more established storylines (Bosman *et al.*, 2014). However heat networks appear to be one fora within which wider debates regarding the relative role of state and market are being played out. As one interviewee framed it;

> ‘there is genuinely a populist feeling of we should do something different, we should use the resources we’ve got in the city to do things better. We’ve always had a very individualistic approach to things…we want the local authority in our way as little as possible in Britain, that has changed to some extent and the local authorities have to some extent been trying to get that ‘we will be your champions’ mantle. Big government’s not working, central governments not listening to us, we’ll do it locally’ (interview 17-LA).

The (re)municipalisation storyline was evident in a range of local authority, NGO and consultancy interviewees actively discussing the relative benefits of different forms of local state, community and private ownership (interviews 3-NGO, 15-NGO, 17-LA, 19-LA, 23-C). This included municipal energy companies being presented by some local actors as able to;

> ‘reflect what the community want. Its democracy in action. It’s not some private company that’s only interested in profit. How it’s owned influences the decision-making and I think that’s right. If the council wants to push revenue because that’s what the residents want then that’s what we’d do. As long as there’s long-term development and planning I think that’s ok’ (interview 17-LA).

This is not to say that local authorities were presenting their decisions on heat network ownership models as exclusively political debates, as traditional business case assessments of the risks and benefits of different models were central to decision-making. Local decision-making on ownership and operation, although highly complex and locational specific, tended to be significantly driven by the overall objectives of the project and the attitude of the local authority to the balance between an acceptable level of risk and the desire for control. This process is well established in the heat policy literature (Heat and the City Project, 2017; Rao *et al.*, 2017) but the findings of the interviews suggests that many local authorities may be increasingly focussed on the benefits of local control in order to deliver a broad set of benefits, such as regeneration, fuel poverty, economic growth and carbon emissions.

Although it is too early to empirically assess whether this has translated into a significant increase in local authorities adopting publically controlled ownership models[77] certainly interviewees in all three cases, and beyond, were indicating that their interest in local ownership models had increased. For example Bristol indicated that they

> 'want the control basically and don't want to give it away to E.On or Cofely….If we get a third party to invest they're generally going to want to see a higher return than we would and that's got to come from somewhere and it either comes from us charging more or from less revenue going back to the city' (interview 17-LA).

Publically owned or controlled schemes were described as tending to have fewer consumers issues, lower prices for the fuel poor and an ability to have 'priorities that go beyond profit' as well as 'local accountability' (interviews 9-NGO, 21-C). Additionally the focus by many local authorities on 'prices, fuel poverty or having some sort of situation that encourages regeneration through cheaper bills, income generation' was described as 'pushing you towards a cheaper borrowing, public sector approach because you can lever in that

[77] The majority of projects, including the three case study cites, are still developing their commercialisation and delivery plans.

cheaper cost of capital and therefore give you the margins to be able to fulfil some of those other objectives' (interview 21-C). This finding echoes the work of Hannon and Bolton (2015) and Webb (2015) in their analysis of Energy Service Company (ESCo) models and Aberdeen Heat and Power respectively which emphasised how municipal involvement can be framed as a route to securing wider social and environmental benefits.

Increasing interest in municipal control was also framed in relation to the financial cuts that local authorities have by subject to since 2010. Developments in Bristol resonated with this with Bristol Energy indicating that 'In a time of government cuts for local councils, including the end of the revenue support grant from central government in 2020, we exist to provide a strong and consistent revenue stream for Bristol – an investment that will benefit the city and its communities' (Bristol Energy, 2015). An interviewee that works with a wide range of local authorities also suggested that devolution and the ability for council to raise capital has been influential in changing local authorities approach to heat network ownership;

> 'I was looking back at some old reports about how we can fund this stuff and it was 'we can't, we haven't got any money', and now it's 'well we can get money if there's a case for it'. That relaxation of the borrowing rules has unleashed them a little bit…If they have a business case they're quite happy to borrow against it in a large number of cases...So I guess actually if you're trying to put your finger on a change that is it. The view that they can obtain their financing if they want to and they just have to be able to ensure themselves that they can pay it back and get some benefit out of it – against one their requirements or return on investment or probably a bit of both' (interview 23-C).

Although the three cases studies in this research were pursuing different ownership and operation models they all highlighted how the process of determining these choices was value laden and political and went beyond simplified characterisations of differing local circumstances. Several local actors also suggested that (some) cities were better able to engage actively in energy activities where effective mayors and other political leadership was in place. This included an interviewee suggesting that ‘some city mayors are more advanced in their thinking that national government and national government is a very slow moving body compared to more dynamic cities’ (interview 16-LA). The theme of political leadership was particularly referred to in relation to Bristol, Manchester and London, which all have high profile climate change strategies backed by elected mayors. Of the case study cities political buy-in was highlighted as significant in setting a stable strategic framework and securing resources in both Birmingham and Bristol. In Bristol both the previous mayor, George Ferguson, and the current Mayor Marvin Rees[78] promoted the role of heat networks as part of the city’s journey to becoming carbon neutral. However, despite this political buy-in, the development of heat networks tended not to be a high profile issue in the city’s climate change plans and whilst residents of social housing connected to the networks have been engaged in network development there is limited wider community engagement or awareness of the heat network projects.

In Birmingham, when the Broad Street and Eastside schemes were developed, the Deputy Leader of the council, Councillor Paul Tilsley, promoted the development of heat networks and recruited officer champions from various council departments. Elected member support was described as instrumental in developing support for the city to take a leadership role in sustainable energy and develop heat networks (Sustainability West Midlands, 2014; Climate KIC, 2015).

In Bristol the development of heat network plans took place at the same time as the development of the Bristol City Council energy supply company (Bristol Energy). This introduced a storyline of local authority (re)engagement in the energy system to senior management and elected representatives which appears to have been helpful in supporting the development of council owned heat networks. It also increased senior management willingness to engage in

[78] Ferguson was the first elected mayor of Bristol between 2012 and 2016. He was an independent candidate. Rees was elected in 2016 and is a Labour politician.

‘novel’ energy activities. In this context income generation potential and concerns regarding the loss of strategic control were repeated highlighted as key in evaluating heat network business models (Bristol City Council, 2016a).

Both Sheffield and Birmingham have a history of delivering heat networks via commercial partnerships but indicated, that although they may continue to deliver some networks via such partnerships they are also exploring the potential for a more central council role in future networks, acknowledging the potential for revenue raising and greater control. An interviewee involved in Birmingham suggested that the city is;

> ‘one where the city council felt most let down by the fact that they [Cofely] delivered these little bits and then it just stopped and the barriers in terms of the required financial returns to make anything else happen were so high so they could see nothing was going to happen so Birmingham have gone out and been actively looking at different ways of doing things’ (interview 23-C).

This resurgence of interest in the role of local government in the energy sector was also adopted at a national level by the Association of Public Service Excellence (APSE), the Institute of Public Policy Research (IPPR) and the Core Cities Group[79]. The core message of these organisations tended to relate to the potential benefits of increased public sector involvement and ownership across the energy sector (Platt *et al.*, 2014; Core Cities Group, 2013; APSE, 2013) but heat networks were used as a prominent example of an opportunity for public ownership. APSE in particular identify a growing role for local government in the energy sector and refer to increased interest from local government as a move from an ‘enabling’ to an ‘ensuring’ role (Bramah, 2014). This is detailed in their 2013 publication ‘Manifesto for the Ensuring Council’ which suggests that the ‘enabling’ model of local government as commissioners rather than providers of services may be being challenged by an alternative ‘ensuring council’ model. The report highlights the democratic legitimacy of local authorities and their role in placing politics and public value before reliance on competitive markets. They

[79] The Core Cities group represents England’s eight largest city economies outside London as well as Glasgow and Cardiff.

also launched ‘APSE Energy’ in 2014 which aims to support local authorities to collaborate to ‘enable and facilitate the local municipalisation of energy service’ (APSE, 2013: 1). APSE Energy provides knowledge sharing between local authorities, legal and procurement advice and support, and runs events and workshops.

Similarly IPPR published a report on city energy in 2014 that suggested that cities could ‘transform’ efforts to decarbonise the energy system and offer an alternative to the established utility companies (Platt et al., 2014: 1). This followed the Core Cities publication of ‘Power Up the Cities’ which suggested that the group ‘will use their combined strengthen to establish energy companies’ and that heat network deployment is ‘often limited in the commercial sector by short-term single company commercial reward and risk criteria. Local authorities can take a more strategic and long-term view’ (Core Cities Group, 2013, pp. 1–2).

There is some recognition in industry that a stronger role for local authorities is likely in relation to heat network ownership with an industry interviewee stating that the

> ‘reality for retrofit is that it’s not attractive for the private sector, there isn’t any money in it, let alone enough…If you want to reduce fuel poverty only the public sector can provide that sort of service because of the lower return requirements they have and the availability of cheaper finance’ (interview 22-DHU).

The suggestion that joint ventures with local authorities are likely to become more frequent while design, build, finance, operate and maintain (DBFOM) concession contracts[80] are likely to become less common was supported by Engie’s announcement in 2016 that they will move away from their established DBFOM concession model to focus on providing management, operation and maintenance services rather than asset ownership (King, 2016; interviews 18-DHU, 20-DHU, 22-DHU).

[80] Such as the arrangement in Birmingham.

A number of local government and NGO interviewees highlighted the limited opportunities to engaging in productive debates regarding the role of the local state in the ownership of the energy system, due in part to the strength of the market liberal paradigm in the UK (interviews 14-C, 19-LA). So while many local authoritiess are opening up new discussions regarding their role in energy infrastructures there is very little parallel debate at the national level, outside of framing local government's role as one of brokerage. This also demonstrates that the roles local government can take in the energy system are to some extent contingent upon domestic political institutions with the UK's political and institutional regime historically leaving little space for local government involvement in the energy system. Certainly there was an awareness in local authorities of their limited capacity to engage in policy debates due to capacity issues (interviews 8-LA, 11-MU, 17-LA). This suggests that a number of conflicting storylines might be interacting at the scale of heat networks with a range of broader governance trends (relating to decentralisation of powers, the need to raise revenues and disappointment in contracting out services) driving local authorities to reassess their role in infrastructure development. However, at the same time the ability of local government to engage with energy infrastructure planning and delivery is limited by the existing governance framework where local government has limited local powers and energy system norms do not recognise a central role for local government (Webb, 2015; Hodson, Marvin and Bulkeley, 2013).

There is growing recognition in academic literatures that the transition to a low carbon energy system is likely to create new spaces of agency at the local level (Bulkeley et al 2011, Hodson and Marvin, 2010). Hall, Foxon and Bolton (2014) illustrate how the range of actors involved in the energy system is diversifying as decarbonisation progresses, both to include a wider range of private companies and investors, and municipalities, communities and citizen-investors. They focus on the emergence of municipal energy companies, regional energy planning, community energy schemes and citizen investment models and term this the 'civic energy sector'[81]. Together with Barton *et al.* (2015) they suggest that this sector could become a substantial element of the UK energy system. This suggests that alternative – and specifically municipal and community – models of ownership may be growing in importance across the energy sector. Given that this may be particularly the case for heat networks it is somewhat surprising that this discourse is not reflected to any significant degree in national heat network policy debates.

Overall this section indicates the ideational basis upon which some local actors were forming storylines relating to heat networks with the local government role positioned as part of a wider movement to 'remunicipalise' elements of the energy system. Indeed as Cumbers and McMaster (2012, p. 165) argue, 'debates on re-municipalisation often reach far beyond questions of legal and material ownership to include issues of local community control, distributional justice, environmental sustainability and justice and enhanced participation – collectively termed ideational ownership'. This highlights how ideas about the role of the local state, control and equity are embedded in these discussions.

5.5.4 Regulation and Consumer Protection

To date the approach towards regulation and consumer protection in England has been focussed on industry-led, voluntary standard in the form of the Heat Trust and the CIBSE Code of Practice. These developments were welcomed across interviewee groups and described as a common sense route to addressing some consumer protection issues and increasing consumer trust. Voluntary standards were framed as 'quick wins' that could be pursued regardless of other policy action (or inaction) and industry interviews suggested that 'at this embryonic stage of development it's much more important to self-regulate than fully regulate' (interview 22-DHU).

The 2013 Heat Strategy (DECC, 2013b, p. 38) echoed this concern regarding over regulating a small industry and ruled out the regulation for heat networks in the short-term, announcing that Government 'will seek to endorse an industry-

[81] Barton *et al.* (2015) also refers to the Civic Energy sector.

led consumer protection scheme'. This was supported by several industry representatives based on the belief that the Code of Practice and the Heat Trust 'will increase confidence in the sector and the [financing] gap will gradually diminish whilst attracting a secondary market of longer term – and lower cost – institutional investors' (King, 2015). However, several interviewees suggested that these measures were having limited impact to date due to the relatively low membership of the Heat Trust;

> 'our biggest concern around the Heat Trust is that not enough people will sign up and I think that's broadly been proven to be true as, as ADE will tell you, there's been lots of people who've said 'we're interested' but unfortunately it's not had a huge number taking it up. I think the only people who've signed up so far are E.On and GDF Suez/Cofely, so the two biggest operators in the market who you would expect have the processes and resources in place to be compliant anyway…In our conversations with local councils they said 'we'd love to sign up to a consumer protection scheme but we're worried about the cost' (interview 24-NGO).

In a similar vein there was acknowledgment from many policy and industry actors that industry standards and consumer protection measures are likely to need to be formalised in future to ensure minimum levels of consumer protection as more people are connected to heat networks (interviews 7-DHU, 22-DHU). A number of interviewees pointed out that central government funding or local government concession contracts could effectively make existing voluntary standards mandatory by requiring membership of and compliance with the Heat Trust and the Code of Practice as a condition of funding or contracts. Indeed the Heat Networks Investment Project application guidance requires that eligible networks are a member of Heat Trust or equivalent. However these discourses, based on a perceived 'sensible' and 'step by step' approach, are generally focussed on the short-term development of a heat network industry in England and there was a theme from NGOs and local authorities that this approach was limiting debate of alternatives and long-term regulatory certainty. Heat networks were described as operating in a ‘regulatory vacuum’ which was undermining existing support and increasing the cost of capital (interview 15-NGO). Discussion of longer-term routes to ensuring consumer protection and industry quality such as mandatory industry standards, network operator licensing, heat price oversight or regulation, access to an ombudsman or the zoning of heat network areas was very limited with the government focussed on establishing an industry before ‘burdening’ them with regulation.

Consumer protection groups, unsurprisingly, suggested that more attention needs to be paid to consumer issues particularly as it was suggested that there was limited incentive for existing poorly performing schemes to join the Heat Trust as they already have a captive customer base so do not need to join the scheme in order to attract new customers (interview 9-NGO). Likewise several interviewees suggested that membership of the Heat Trust favoured established players who were involved in the development of the scheme and were likely to be better able to afford membership fees than smaller, particularly local authority or community owned, schemes.

5.6 Key events and windows of opportunity

Hajer's (1995, p. 271) seminal analysis of environmental policy-making in relation to acid rain highlights how ‘sensory experiences’ – including meetings, events and excursions[82] – could be both employed to influence policy and come into conflict with other institutional norms such as the need to provide scientific evidence of a phenomenon.

In relation to heat network development in England a number of events and face-to-face interactions were revealed as important by interviewees. These events tend not to be referred to in policy documentation as an important role for individuals and events does not tend to fit well within perceptions of the policy process as rational and evidence led. Despite this a number of interviewees highlighted the appointment of David MacKay as Chief Scientific

[82] Hajer specifically referred to the role of parliamentary excursions to sites of dying trees as well as meetings and events.

Advisor within BEIS in 2009 as part of the reason why heat networks were not initially given a prominent role in decarbonisation policy[83]. Although the influence of MacKay was highlighted by several interviewees it seems that reference to Mackay was used as a shorthand to represent the problems related to relying on an all-electric future as interviewees also identified that the technology preferences of a number of other individuals were key in side-lining heat networks, including various Secretaries of State and senior DECC/BEIS staff (interviews 3-NGO, 14-C, 27-G, 28-A). One interviewee suggested that BEIS 'don't really like district heat at all, there's something within, particularly the higher officers within DECC, that doesn't like it and I've never really quite understood why' (interview 27-G).

Face to face interactions between ADE and BEIS, in the form of regular formal and informal policy discussions and events, appear to have been significant in developing rapport and trust between policymakers and the industry body. Both organisations benefitted from this cooperative process as the policy advice and numerous working groups that ADE coordinated were an important source of industry information and informal consultation, in what interviewees described as an overstretched heat network team within BEIS. One interview specifically suggested that ADE played a role in providing evidence to BEIS to support officers with the department to 'win the arguments internally' on heat networks (interview 27-G). Likewise ADE benefited from a close relationship with BEIS as they could demonstrate that they were representing their member's interests in the policy development process.

A study tour to Denmark which ADE organised was highlighted as particularly significant in developing support for heat networks across BEIS. This was presented as 'We needed to get David Wagstaff [Head of the Heat Directorate in BEIS] out to see heat networks in their context…within a month or so of his appointment we took him to Copenhagen and Malmo…That led David to take the initiative and then more people got it and now we have a heat industry directorate and all of a sudden heat has risen up the agenda. And that really

[83] See section 5.4.1 for further discussion of MacKay and an 'all electric future'.

was the seed of it' (interview 29-TA). The study tour acted to embed personal connections between individuals within the government department and ADE and to consolidate working relationships on future policy development. Interestingly the study tour does not appear to have translated into extensive debate of ownership and regulatory models although the Danish system operates under a not-for-profit model where networks are either municipally or community owned and municipalities often act as guarantor to district energy companies[84]. Instead the feedback from interviewees was that this trip impressed on attendees the feasibility of high penetrations of heat networks and the role they could potentially play in delivering wider energy system services such as flexibility, grid balancing and storage. This demonstrates how institutional norms can strongly shape the discursive space open to discuss policy options as the Danish model was described by several attendees as not replicable in the UK due to the different histories[85], energy system requirements[86] and policymaking cultures of the countries (interviews 14-C, 22-DHU, 28-A).

At a local level there was a storyline held between several local authorities and a number of advisory organisations relating to a number of early Cofely schemes in England in shaping current perceptions of concession models. This storyline focussed on perceived problems encountered by local authorities involved in Cofely concession contracts in achieving the desired level of control in network development and not receiving the expected level of profit share. Additionally difficulties in liaising with some key Cofely staff were reported. These issues were presented as spreading across local authorities interested in heat networks in a 'word of mouth' manner and some local government interviewees suggested it influenced their reluctance to pursue an ESCo concession model (interviews 14-C, 25-LA, 27-G). As one local authority interviewee put it 'if you go too early with an investment company that know

[84] KommuneKredit, a credit union for Danish cities, lends out more than DKK1 billion (€135 million) annually to district energy companies where municipalities act as guarantor (UNEP, 2015).
[85] The initial policy focus on heat networks in Denmark took place in the wake of the 1979 oil shock when the UK was starting to exploit indigenous gas reserves.
[86] Denmark has a relatively low population, concentrated in a small number of cities and extensive biomass resources.

what they're doing they're going to probably tie you up into a contract that is not in the best interests for you as a city. The Birminghams, Southamptons they couldn't be more annoyed about how things were set up and we don't want to go there' (interview 17-LA).

These examples of key events also demonstrate the importance of individuals in heat network policy development in the UK. The Danish visit, the appointment of MacKay and the poor performance of some Cofely scheme were all related to the role of key individuals. Likewise all three English case studies were shaped by 'wilful individuals' with Mayors, Councillors, Senior Management sponsors and committed project staff referred to as pivotal in all three cases. The importance of individuals in shaping infrastructure systems has been recognised since Hughes' (1983) work on electricity infrastructure which stressed the importance of motivated and entrepreneurial system builders in overcoming both technical and non-technical barriers. This reliance on individuals has been identified as particularly important in relation to heat networks 'due to the lack of an overarching regulatory and policy framework' (Bolton, 2011, p. 210). Bolton goes on to suggests that the 'political nature of councils means that there are a number of tiers of decision making within a centralized and hierarchical structure which makes individuals or technical and political champions particularly important agents of change within this highly structured environment' (Bolton, 2011, p. 211). However this importance of individuals should be seen in the context of an equally important role for complex actor networks. In her study of the development of a district heating scheme in Sweden, Jane Summerton highlights the importance of what she terms a 'multi-organisation' or an 'invisible grid' where actors 'functionally interact to achieve a shared purpose, performing different roles in support of the system (…) this may be centred around a central body or focal organisation that has specific planning, coordinative and decision-making functions' (Summerton, 1992: p.79). These 'multi-organisations', which bring coherence to a sometimes fragmented set of energy institutions and technologies at the local level, are unique to each of the schemes involving different relationships between public and private actors and different approaches to the planning and operation of the energy systems themselves.

The case study cities also demonstrated the importance of both historical context and windows of opportunity in heat network development. Due to the long-term and complex nature of heat network development successful projects require the alignment of multiple interests and, the case studies suggest, require a range of external factors to align to create a compelling case for the commitment of key actors to long-term and potentially risky projects. Specifically wider momentum relating to the cities commitments to carbon reduction were significant in creating an arena in which heat networks could be aligned with decarbonisation plans. In Bristol the opportunity to apply for ELENA funding, the achievement of European Green Capital and the appointment of a City Mayor with an interest in environmental issues all served to focus local actors on decarbonisation, allowing heat network projects to be incorporated into long-term energy planning. Likewise in Birmingham the regeneration of areas of the city centre presented the opportunity to develop masterplans for central Birmingham at the same time as the council was developing climate change projects.

As discussed in section 5.5.2 regarding the role of local authorities in heat networks, twin themes were identified in relation to both (1) constrained local authority finances and (2) local governance devolution opening space for local government to reconsider their role in various sectors. This was framed by a number of subnational interviewees as creating a 'window of opportunity' for the role of cities in the energy transition to be re-examined. Although this opportunity was identified in some interviews, and in a number of published documents, it was far from a consensus storyline with many interviewees focussing on market based models of heat network delivery. This illustrates how although windows of opportunity can be important routes to allowing a storyline to begin to be shared by groups of actors the persistence of powerful institutional discourses can still act to block new storylines.

5.7 Coalitions and actor networks

The presence of shared storylines in relation to a specific policy arena can be identified as a discourse coalition and Hajer (2006) suggests that the dominance of a discourse can be partly determined by reference to both the extent of its use and its use by identifiable discourse coalitions. Analysing discourse coalitions can be helpful in exploring discourse structuration as they can indicate the location of commonalities in storylines between actors and which storylines and discourse are most widely used. This section explores how heat network discourses are being structured in England through their use by formal and informal coalitions and how various key groups are acting to coordinate storylines.

5.7.1 BEIS and the HNDU

The existence of the HNDU since 2013 was consistently emphasised as a key development and was characterised as providing valuable resources and support to local authorities. However the HNDU, and the Heat Directorate in BEIS more broadly, were also described as overstretched and side-lined with several local authorities and consultants questioning whether the approach of funding many feasibilities, instead of supporting a smaller number of key schemes through to delivery, was the most effective route to developing heat networks. This included a concern that many feasibilities would be ‘just sat on the shelf’ (interviews 4-G, 13-C, 17-LA, 19-LA, 23-C, 28-A). It should be noted here that the interviews that form part of the basis for this research were carried out before the announcement of £320m of commercialisation funding through the HNIP. However, it is too early to assess the proportion of projects that were funded by the HNDU that progress to delivery and/or are supported by the HNIP.

In terms of the wider actor networks liaising with the HNDU local interviewees indicated that local authorities had a ‘voice’ in the HNDU but questioned whether that feeds through to policy development (interview 15-NGO). In particular there was respect for the experience and commitment of individuals within HNDU but the perception that they had limited influence on policy development as the unit is focussed on delivery. Many of the individuals within the HNDU had a local authority background and were generally operating on a peripatetic basis so it is somewhat unclear the extent to which they are integrated into the wider civil service culture or influenced the policy direction in

BEIS. Certainly local authorities and other industry commentators framed the HNDU team and other members of the heat directorate as part of the same coalition at themselves and suggested that the 'the border line not between us and them but between them and other people in the department' (interview 14-C).

While the HNDU has clearly been an important factor in accelerating local authority activity on heat networks the department's own evaluation of the Unit suggested that most local authorities had already been progressing heat network projects before the HNDU team supported them and had (and were) accessing other forms of support. This included from universities, the Homes and Communities Agency (HCA), the Vanguard Network, APSE Energy, European funding (e.g. ELENA), and a variety of regional/sub- regional entities including LEPs, Core Cities and the GLA (DECC, 2015e; BEIS, 2018a). This indicates the importance of coalitions and networks to local authorities. In the Bristol this included engagement with the Carbon Trust, the Centre for Sustainable Energy and other local authorities in the city region, as well as European networks. In Sheffield this took the form of long-term relationships with local industries and heat network partners and in Birmingham is spanned both partnerships with local public and private sector organisations and co-ordination with other local authorities in the Greater Birmingham and Solihull Local Enterprise Partnership area (interviews 8-LA, 17-LA, 25-LA).

5.7.2 The role of the Association for Decentralised Energy [87]

As discussed, the ADE was widely identified as a central actor in shaping heat network debates due to their strong links to both the industry and the Government, and to a lesser extent local authorities. There was a high level of respect for their analysis and industry knowledge amongst interviewees however sub-national interviewees highlighted that, although local authorities and consumer groups are represented on some ADE working groups in general there is limited local authority or community energy representation within the

[87] Formerly the Combined Heat and Power Association (CHPA) but referred to throughout this thesis as the ADE for consistency.

organisation (interviews 2-C, 3-NGO, 4-G). This is supported by analysis of their membership base with only 10 local authorities as heat network members, from a total of 68 organisations.

Similarly the ADE coordinated the development of the Heat Trust which several local authorities highlighted was difficult for smaller organisations and local authorities to join due to costs and membership requirements that favoured large organisations, such as the requirement to have a 24 hour enquiry/emergency call centre. To date there are no local authority Heat Trust members with membership limited to six commercial companies who operate 41 networks in London and 10 networks outside of London.

The approach of the ADE was also framed by a range of actors as initially focussing on areas of uncontentious policy agreement in order to establish a coalition of support which gave them a mandate to work closely with BEIS and established their key advisory role. These ‘easy win’ policy areas included the development of a consumer protection scheme and industry standards (in the form of the Heat Trust and Code of Practice).

The ADE appears to have established itself as a focal point for dominant narratives with the government’s approach to supporting heat networks, from 2012 onwards, closely reflecting the advice of the ADE. For example ADE launched the ‘Big Offer’ in November 2012 which advocated seven key actions to promote the growth of heat networks (ADE, 2012). This included a commitment from ADE to establish a customer protection scheme (now the Heat Trust) and a request for government to provide short-term support to heat network development (which became the HNDU). Table 10 illustrates the elements of the Big Ask and the status of each point, with only the development of loan guarantees not yet delivered.

Table 10: ADE Big Offer elements and current status

Big Offer elements (November 2012)	Current status
District heating database of opportunity	Delivered - Heat Map has been developed for England and Wales

District heating development support agency	Delivered - HNDU launched in September 2013 and ongoing.
District heating development fund for local authorities	Delivered - HNDU administers grant support for local authorities to support Heat mapping, Energy master planning, Feasibility studies, Detailed project development, Commercialisation.
District heating contract framework	Partially delivered - The District Energy Procurement Agency (DEPA) has been developed with financial support from BEIS. DEPA is a municipal not-for-profit procurement cooperative specialising in goods and services in the district energy market which aims to reduce heat networks project costs in the UK through joint procurement.
Loan guarantees for district heating	Not yet agreed but the HNIP has made £320million of heat network capital funding available to unlock finance.
Customer protection scheme	Delivered - Heat Trust consumer protection scheme launched in 2015.
Industry support for Government policy making on district heating	Delivered - Various working groups convened. ADE has established a 'Post-2020 Heat Network Arrangements' to advise government.

The ADE have also been a strong voice advocating for the prioritisation of access to finance and promoting the adoption of mainstream financial terminology in policy discussions. In their response to the Energy and Climate Change Select Committee on Heat in 2013 (CHPA, 2013) they welcomed the establishment of the HNDU but suggested that support to attract long-term investment funding and bespoke financial support were areas that required more focus[88].

This theme has continued in their interactions with the Scottish Government on heat networks where they responded to the consultation on the regulation of heat networks by arguing that clear commercial contracts and concession agreements will enable the delivery of a wide range of outcomes 'akin to

[88] They also highlighted the need to maintain planning requirements that support heat networks.

regulation' (ADE, 2017a). They also highlight their taskforce on 'Post-2020 Heat Network Arrangements' which is focussed on how to reduce investment risk for heat networks to a comparable level with new gas, waste and power network investments. They cite the need to 'completely or near-completely de-risk heat network revenues' and highlight how the Scottish government could guarantee set heat revenues to network concession holders, citing similar current arrangements in PFI contracts. In the consultation response they go on to indicate that it is important that concessions remain under the control of local authorities but that local authorities may be conflicted when issuing or enforcing concessions held by companies in which they are involved. They suggest that concessions should be 'viewed as a local authority procurement exercise, where the local authority is contracting with the best private sector provider to deliver a set of social, environmental and consumer outcomes, there is arguably a more transparent commercial relationship between the local authority procuring the service and the commercial body delivering it' (ADE, 2017a, p. 7).

In summary the ADE have promoted two core storylines – both of which have developed considerable purchase with government – of promoting an industry led approach to regulation and advocating that government policy focusses on addressing financial barriers to heat networks. While these two issues are likely to be helpful to supporting heat network developments, ADE have co-opted actors onto these priority storylines through their close relationship with the heat team in BEIS and their extensive industry presence. This has somewhat limited the ability of competing discourses to have influence, including those of local governance, regulation and consumer protection.

5.7.3 Local authority discourse coalitions

As discussed in section 5.4.2 an emerging narrative was evident amongst sub-national actors regarding the benefits of local government control of heat networks and the remunicipalisation of energy infrastructure. Although shared by a range of local authorities and local governance organisations this emerging storyline was by no means universally held by all local authorities and even when used tended to be interpreted in a range of ways. For example some actors framed a more central local authority role as a practical measure to ensure networks were developed with the potential to expand in the future whilst others saw it as an ideological challenge to the diminished role of local governance. This ambiguity can be helpful, allowing actors to fit a storyline to their own interest (Schmidt, 2006) and acting to recruit a wider coalition. However it also demonstrates the difficulties faced by emerging narratives in establishing a coherent message and recruiting coalition members who advocate for similar ideas. Regardless of these different interpretations of the 'local authority ownership' storyline there was a high degree of consensus relating to the ability of a strong local authority role to ensure that wider energy system, social and local economy benefits of heat networks are realised. Additionally a significant number of sub-national interviewees were linking debates regarding the role of local authorities in heat networks to wider, ideological debates relating to the role of the sub-national state in the delivery of social goods.

Bristol and Birmingham provide contrasting approaches in this respect. In Bristol there was a strong emphasis on local authority control and heat networks were being developed in the context of the council launching a municipal energy supply company aimed at providing 'social goods'. Birmingham, in comparison, has a history of partnership delivery in order to reduce risk and, although now interested in the potential for a stronger role for the council in future, sees this in the context of a continued diversity of delivery models.

Notwithstanding the complexity evident in the 'local authority ownership' discourse coalition a range of local governance networks were engaged in this storyline and influential in promoting and adding credibility to this discourse. For instance the Core Cities Group, APSE, District Energy Vanguard Network and a range of other local authority networks[89] all promoted either a storyline of energy remunicipalisation or of the role of local government in realising the wider benefits of heat networks. Whilst this helped to establish the storyline within a sub-national actor network it has had limited resonance with national discourses.

[89] Such as the South West Local Authority District Energy Network.

5.8 Institutionalisation

As discussed in chapter 3 this research aims to explore the processes by which heat network actors are both constrained by institutional frameworks and influence these frameworks through discursive interactions. This section explores this relationship through scrutiny of the institutional practices in which discourses are produced including change and maintenance of existing structures and the failure of efforts at institutional change. Chapter 7 explores how different types and levels of ideas interact with discourse and institutions, and the concluding chapter relates the findings of this research to the research questions and makes a number of conclusions regarding how an examination of heat networks in England and Germany through a DI lens contributes to our understanding of urban transitions.

This section outlines that multiple storylines and ideas are being embedded into heat network institutional structures in England. This complexity, and the sometimes contradictory storylines being embedded at different scales, reflects the limited nature of current governance structures for heat networks and the complex range of actors, interests and ideas involved in energy transitions, particularly in an 'embryonic' industry like heat networks in England. In particular informal institutional structures were revealed to be particularly significant as there are currently limited formal institutions governing heat networks with no independent agency responsible for regulation, licensing or standards and little direct government policy outside of the formation of the HNDU team. Engagement with a range of broader networks was revealed to be important in constructing a case within local authorities to pursue heat network projects. In Bristol this included engagement with informal European networks, such as such as ICLEI[90], Energy Cities[91] and ELENA, which helped the local authority to integrate heat networks into its wider ambitions to be an internationally leading city on climate change action. However city networks, outside of commercial agreements, tended not to be formalised with complex

[90] ICLEI: Local Governments for Sustainability is a network of sustainable cities and facilitates local government input to United Nations (UN) processes such as the UN Framework Conventions on Climate Change and Biodiversity.
[91] Energy Cities is the European Association of local authorities in energy transition.

actor constellations engaging in heat network developments in each of the locations.

Informal institutional norms were particularly significant in shaping debate and the formation of policy options. As discussed in section 5.3 an established storyline of the need to fit heat network business cases into investment ‘norms’ and attract finance through de-risking projects (currently largely through HNIP funding and HNDU support) was promoted by industry actors and strongly evident in Government debates. The reinforcement of these ‘norms’ through storylines adopted by key policy actors such as the ADE and BEIS highlights that argumentation is not as simple as explicit debate and includes more subtle processes such as blackboxing issues by making them appear as ‘fixed, natural, or essential’ (Hajer, 1995a, p. 272). The focus on fitting heat network projects to investment norms therefore positions the need for private investment to be levered into heat networks as undisputable and beyond doubt and acts to marginalise alternative priorities, for example debate of alternative methods of de-risking networks or the implications for financing if a large proportion of networks are local authority owned and financed.

As discussed in section 5.7 much of the current approach to heat network development is based on industry-led consumer protection and self-regulation. The construction of heat networks in England as an ‘emerging’ industry and therefore the importance of not over-regulating at this stage, together with the central role of ADE in influencing debates, appears to have been influential in shaping the government’s approach to regulation. This has led to industry-led regulation being, to some extent, institutionalised through the development of the HNIP as funding requires schemes to specify that developments are part of the Heat Trust and meet the Code of Practice. However interviewees from across sectors emphasised that the future of heat network regulation is likely to be revisited as the number of consumers connected to networks grows and there was a broad consensus that it is likely that some formal regulatory framework would be developed in the future. There was debate amongst interviewees regarding when it might be most beneficial to develop a formal regulatory framework with NGOs suggesting that this should implemented as soon as possible whereas industry and local authority representatives tended to suggest that this should be at an unspecified future date once the industry was established. Industry interviewees acknowledged that this institutionalisation of industry-led consumer protection and regulation may be temporary however current arrangements are also likely to influence the development of future regulation and appear to be one route through which industry groups are attempting to shape the future evolution of heat network regulation.

One of the key storylines identified in this research relates to the role of local authorities in heat network development and operation. As discussed this was an area of both consensus and contestation which was also reflected in the processes of institutionalisation of these discourses. Consensus regarding the importance of local authorities in coordinating heat network projects resulted in a central role for local authorities in heat network support schemes such as the HNDU and the HNIP. However, although local authorities are the core coordination organisations in these schemes and the conduit for funding, the HNDU and HNIP are somewhat ambiguous regarding their role beyond coordination. Additionally strong institutional discourses relating to the need for heat networks to fit within existing energy system structures and the need to attract international finance have acted to block detailed consideration of the unique characteristics of heat networks and the importance of wider social, environmental and economic benefits. Although there was consensus that one of the key benefits of a central local authority role in heat networks was their ability to balance multiple priorities, existing heat network governance structures do not provide a framework to value non-financial benefits and balance a complex range of local and wider energy system benefits. This is further embedded by a lack of institutional structures to engage and represent local governance interests in energy policy. So although a discourse coalition was evident in relation to local authority ownership it had little opportunity to engage with national policy in a coordinated manner.

Outside of specific debates regarding heat networks there was a gradual institutionalisation of a more significant role for local authorities through the development of devolved governance structures which ascribe greater autonomy to local authorities. Although the extent to which this devolution is giving new powers to local governments is contested, this storyline together with a need for local government to identify sources of new revenue, is leading to a wider discursive context that is prompting local authorities to reconsider their role in a range of sectors, particularly in relation to the delivery of infrastructure. However this institutionalisation is taking place within broader governance structures, such as devolution deals and through new powers to be more commercial, rather than in energy specifically.

Increased engagement in the energy system by local authorities is not necessarily easy and an interviewee working with numerous local authorities suggested that while

> 'there is nothing to stop councils in terms of the energy transition we keep coming up against the barrier that is the energy industry and how its structured in the UK. What's starting to happen therefore is that councils are saying actually we need control of the network, we need access, we need to maximise the value to communities and local economies, to do that we need to be in supply, we need to have more control over the distribution network' (interview 19-LA).

This theme of wider energy system structures and institutions not supporting municipal action on decarbonisations is supported by a report from the Energy Research Partnership (ERP) on the role of cities in the UK energy agenda which suggesting that 'City Authorities have no clear mandate to engage in development of the UK energy system and the ability for Local Authorities to take on more fiscal responsibility and engage in energy development is limited given their renewed focus on core services due to austerity measures. However, City or Local Authorities are best placed to enable this co-ordination given the complex socio-technical and socio-economic requirements…There is a tension, therefore, in that central government policies especially around energy are placing a greater need for the involvement of Local Authorities at a time when the capacity for them to engage is being reduced' (Workman, 2015, p. 7).

Notwithstanding the similarities and differences between national contexts discussed, all the cases studied also revealed the importance of locally contingent networks and historic contexts in shaping network development and governance structures. For example in Sheffield a strong local narrative relating sustainable energy to economic competitiveness and the ‘green economy’ was important in creating political momentum for expanding heat networks, as was the cities long history of operating heat networks. The local authority’s familiarity in coordinating action between public and private sector agencies was significant in the development of multiple heat network delivery models but a more recent focus on opportunities for the local authority to develop revenue raising projects appeared to be influencing its approach to future network development. In contrast, in Bristol, a strong narrative of being a leading city on climate change, together with political support for energy projects and a history of local public sector partners working together allowed heat networks to be positioned as an important part of the cities long-term climate objectives. The wider context of the city establishing a municipal electricity and gas supply company, as well as the flexibility provided by a lack of historical delivery models, also prompted the city to reject commercial ownership or financing of the networks.

5.9 Conclusion

This chapter has presented the key themes in the English case studies and national discourses. It suggests that although local history and context are revealed to be significant in shaping heat network trajectories there was greater divergence between national and local discourses than between case study locations.

In particular local actors highlighted how a changing local governance agenda, both in terms of devolution and a constrained financial situation, was interacting with many local authority’s approach to energy, including heat networks. There was little reference to this theme at the national level although there was increasing acknowledgement of the critical local coordination role local government tends to play in heat networks.

Local authorities across the cases identified that they played a unique role locally in mediating the delivery of complex, multiple priorities via heat networks. The cases all identified values outside of financial rate of return as significant drivers for heat network development but also highlighted the difficulty in aligning complex priorities across long timescale and diverse actor groups. In this respect the

Informal institutional structures, such as norms regarding the role of local authorities and financial appraisal practices, were revealed to be particularly significant as there are currently limited formal institutions governing heat networks with no independent agency responsible for regulation, licensing or standards and little direct government policy outside of the formation of the HNDU team. Institutional norms relating to financial appraisal were also identified as playing an important role in constraining the ability of alternative narratives to establish, with strong traditions of competition and private capital embedded in policy discourses. Additionally a lack of institutional structures to engage sub-national actors in energy policy was evident.

Chapter 6: Germany results and discussion

6.1 Introduction

This chapter outlines and explores the findings of the empirical research carried out in Germany. This includes exploration of discourses and actor networks, discourse structuration and institutionalisation. It is based on examination of policy documents, industry reports and 24 interviews with heat network policy actors in Germany. The chapter is presented as follows; the first section of the chapter describes the current status and development of heat networks in the three German case study locations of Hamburg, Frankfurt am Main and Rhein Hünsruck. The following sections then discuss the development of problem definitions, discourses and actor networks, drawing on both the case studies and analysis of national discourses. The institutionalisation of discourses and policy approaches is then reviewed in section 6.7.

This chapter indicates that in Germany there is a strong focus on the potential for heat networks to support decarbonisation and energy system flexibility and less focus on other social or economic objectives than in England. In light of this the policy focus largely was on the need to support gas-CHP, reflecting the political importance of reducing coal use in Germany.

It is argued that there is a broad acceptance in Germany that a range of actors and ownership structures should be involved in the energy system, and institutional structures exist which cement an influential role for municipalities in energy governance. Despite this the context for cities in the energy system is undergoing some change with increasing focus on remunicipalisation and the potential for city utilities to contribute to rapid energy system decarbonisation.

There is less evidence of key events being significant in shaping heat network development than in England and more discursive similarities between the local and national scale. Despite this there were considerable differences in the politicisation of heat networks at the local and national level. Nationally heat networks were presented as unproblematic and largely a question of providing the right financial support, whereas locally all three cases linked decisions regarding heat network development and municipal ownership to wider political changes and other local conflicts.

6.2 Case studies

In the following section the history and key framings of the three German case study locations are outlined. Detailed analysis of these cases is then incorporated into the rest of the chapter.

6.2.1 Frankfurt-am-Main

Frankfurt am Main is the fifth largest city in Germany and has adopted strong climate protection goals since the 1990s. In 1989 the city established an ‘Energiereferat’ (Municipal Energy Agency) and, in 1991, developed a climate change strategy which set targets to reduce greenhouse gas emissions by 50% by 2030. This led to the development of an ‘energy concept’ for Frankfurt with three pillars of energy efficiency, renewable energy and combined heat and power. In line with these ambitious goals a strong narrative of being a ‘leading’ city on climate change action was evident in policy documents and interviews, with several references to the city’s climate change targets exceeding national plans and the city’s role in founding the ‘Climate Alliance of European Cities’, a group of municipalities in Europe formed to reduce greenhouse gas emissions (Friedel, 2010, interviews 31-LA, 34-MU).

A focus on decentralized co-generation was established in the city from the early 1990s and from 1992 the City Council, working with the local utility, incentivised CHP through various incentives and subsidies. In 2000, following electricity market liberalization, the utility was required to stop subsidising CHP (Friedel, 2010), however by this point the main heat networks in the city had been established. More recently the Sustainable Energy Action Plan set a target for the city to be 100% renewable by 2050 and heat networks are highlighted as important in achieving the city’s carbon reduction aims (Energiereferat Stadt Frankfurt am Main, 2008).

There are currently three large heat networks in the city which, together with industrial CHP networks, account for approximately 47% of heat demand in the city, incorporating 12% of households, 57% of commercial buildings and 65% of industry (Steinkrüger, 2014). The three main heat networks are owned and operated by the local utility, Mainova, which is majority owned (>75%) by the city of Frankfurt. Of the three main networks two are fuelled by fossil fuels (coal and gas) and one by waste. The city plans to extend and interconnect the three networks by 2020 and increase the share of renewable heat to 15%, it also plans to modernise the coal station to increase efficiency (Steinkrüger, 2014).

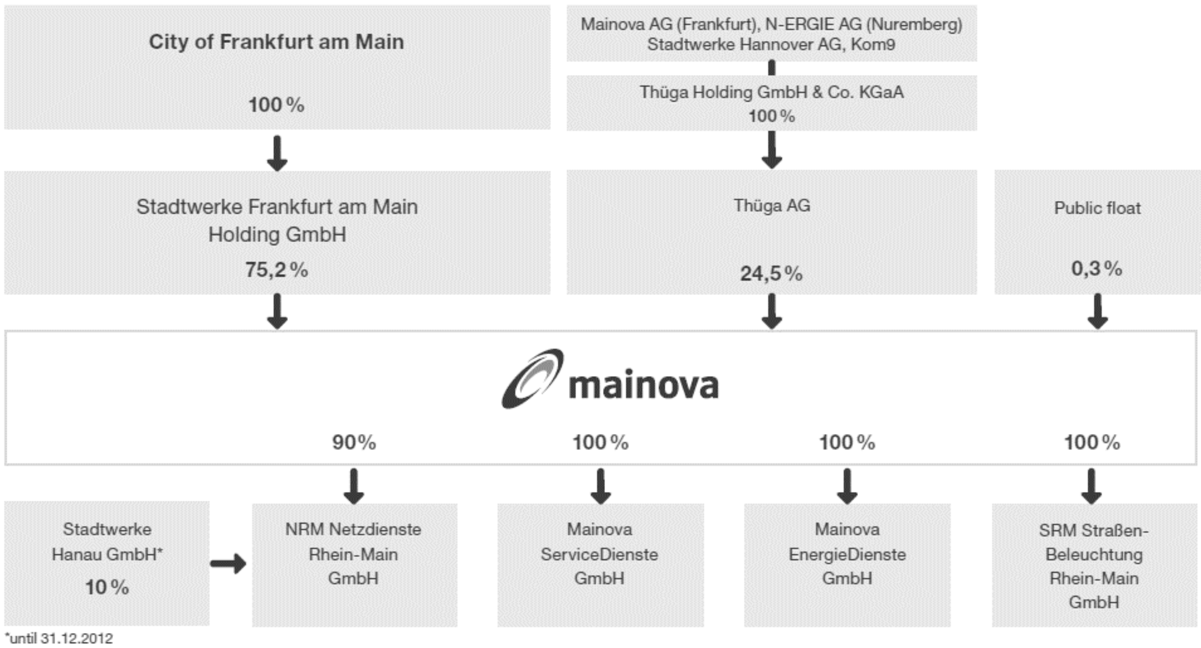
In framing its energy policy the city outlines six roles for local authorities; as an energy consumer, city planner, property developer, energy provider, facilitator and educator (Fay, 2013). To bring these roles together the local authority takes responsibility for developing a city-wide energy strategy, integrating this with urban development and providing various coordination services, including the development of various tools for the technical, economic and environmental evaluation of CHP and heat network projects. This included detailed modelling of options for delivering the 100% renewable target by 2050[92] which identified renewable heat networks as an important part of the city's strategy. More specifically the Energiereferat produces 'energy concepts' for individual urban districts and development areas which determines whether an area will be connected to the heat network (Friedel, 2010). Connection can then be required via a local statute, although this is rarely implemented.

As discussed the main heat networks in Frankfurt are owned and operated by the local utility Mainova. Although majority owned by the municipality, Mainova operates under a complex ownership structure which has undergone several changes since the 1990s. Initially Mainova was fully municipally owned but in 1996 it was partly-privatised with 24.5% sold to Thüga, a subsidiary of E.On. In 2009 Frankfurt, together with a consortium of municipalities[93] seeking to extend

[92] Produced by the Fraunhofer Institute in Stuttgart
[93] The consortium is called Integra/KOM9. Integra consists of a consortia of Enercity (Stadtwerke Hannover AG), Mainova (Frankfurt), and N-ERGIE (Nuremberg) with each acquiring 20.75% of Thüga shares. The KOM9 consortium is made up of 45 German municipal utilities and acquired 37.75% Thüga shares.

their energy investments, bought back Thüga resulting in Frankfurt owning over 20% of Thüga. So although the utility is not entirely owned by the city government they directly and indirectly hold over 75% of shares, as outlined in figure 19. Following the purchase of Thüga the city merged Mainova with other municipal services to create a multi-utility which sold electricity, heating, natural gas, water and energy services. Part of the rationale for this merger was to avoid various elements of the local utility competing for customers, for example between gas supply and connection to the heat network.

Figure 19: Ownership structure of Mainova



(Fürniß, 2012)

The focus on heat network development in Frankfurt is on expanding and interconnecting existing networks and reducing the carbon intensity of heat, rather than the development of new networks. This involves both the development of renewable heat projects which feed into the heat grid and improvements to the coal and gas plant to reduce emissions. Although Mainova are responsible for the development and operation of the heat networks the municipality supports this through the Municipal Energy Agency working with spatial planning team to phase development of the network with new developments and areas of regeneration.

6.2.2 Hamburg

Hamburg is Germany's second biggest city and one of three city-states[94]. It is an industrialised and densely populated city which also has a high profile for environmental action, including being awarded European Green Capital in 2011. Climate protection projects have been in place since the 1990s and in 1997 the city implemented a local 'Klimaschutzgesetz' (climate protection law) which requires certain levels of energy efficiency in buildings, set standards for new buildings and banned electric heating (Walberg, 2010). In 2007 the city government developed a Climate Action Plan and in 2010 it adopted a Climate Protection Masterplan to 2050 which included an ambitious target to reduce carbon emissions by 40% by 2020, compared to 1990 levels (City of Hamburg, 2011).

Historically the city of Hamburg owned a local public utility called Hamburger Electricity-Werke (HEW) but following liberalisation HEW was privatised in the early 2000s and sold to Vattenfall. Privatisation took place under a SDP-led local government and the process was not without controversy with the former CDU mayor Ole von Beust suggesting in 2007 that the sale was a mistake and that the state monopoly had been replaced by a 'quasi-monopoly on the private side' (Speigel Online, 2007). Under a new coalition government a new municipal energy company called Hamburg Energie was established in 2009 in order to advance the city's climate protection objectives. Hamburg Energie is a relatively small company[95] and is a subsidiary of the existing municipal water company, Hamburg Wasser. It operates a small number of heat networks and is involved in several projects that seek to integrate heat networks with renewable energy and storage (interviews 35-NGO, 47-MU). This includes the 'Energy Bunker' project where a former air raid shelter that has been converted into a renewable power plant, with a large heat reservoir. The bunker utilises solar energy, biogas, wood chips, and waste heat from a nearby industrial plant to heat most of the Reiherstieg district and feed renewable power into the electricity grid. Hamburg Energie is governed by a 20 member board consisting

[94] Together with Berlin and Bremen. There is no additional Land-level government in these states.
[95] With approximately 40 staff and 120,000 customers across electricity, gas and heat at the time of interview.

of 10 private clients and 10 community representatives and associations, such as the Tenants' Association and the Chamber of Commerce. However, Becker, Naumann and Moss (2017) in their study of energy provision in Berlin and Hamburg suggest that the board has limited influence over the actual business practices of the utility.

Heat networks in Hamburg currently account for 20% of heat supply. A number of organisations operate heat networks in the city, including Hamburg Energie, E.On, Orbana, RWE and Spie. The largest network, accounting for over 80% of heat supplied, is owned by Vattenfall and is in the process of being transferred back to the municipality following the referendum described below (Walberg, 2010).

In September 2013 a city-wide referendum took place regarding the remunicipalisation of the distribution grids for electricity, gas and heat operated by Vattenfall. The remunicipalisation campaign narrowly won with 50.9% of the vote. The campaign in favour of remunicipalisation was led by a diverse range of civil society organisations and was framed by interviewees as the culmination of a 'long history of energy-related conflicts in the city' (Becker et al. 2017, p.68, interviews 32-A, 35-NGO) which led new networks of actors to involve themselves in the politics of energy infrastructure in the city. In particular two significant energy conflicts have been pivotal in shaping the discursive environment for energy in Hamburg; the development of the Moorburg and Wedel power plants.

Firstly, in the early 2000s, after having purchased HEW, Vattenfall initiated plans to develop a new coal fired power station at Moorburg. At the time the CDU controlled city government supported these plans as they were seeking to expand the heat network and to shut down the inefficient, old coal-fired power plant in Wedel. As the profile of climate change issues increased nationally and internationally in the 2000s the development of a new coal power station become increasingly controversial with the Green Party and environmental groups opposing the Moorburg plans under the slogan 'Coal Kills the Climate' (interview 46-C). Vattenfall was given a preliminary construction permit in 2007 but following the 2008 state elections the Green Party formed a coalition government with the CDU and initiated a review of the Moorburg power plant's environmental permits. The Green Party also began to push for the development of Hamburg Energie, in order to ensure the city had more control over future energy developments (interviews 46-C, 47-MU). This review imposed increased environmental protection requirements on Moorburg which Vattenfall contested via legal action against the city-state's Office for Urban Development and the Environment. This dispute was settled in 2011 with Vattenfall winning a new water permit with significantly lower the environmental standards that originally imposed (Provost and Kennard, 2015). Moorburg is currently operational as an electricity only plant and is not connected to the heat network[96].

Secondly, Wedel was a coal fired power plant owned by Vattenfall with the city government holding a 25.1% share. It was originally developed in the early 1960's and feeds heat into the heat network. At the time that this research was carried out the future of the plant was subject to extensive debate as it neared the end of its operating life and a decision regarding its future was required before the transfer of the heat network to Vattenfall in 2019. The Hamburg senate were negotiating with Vattenfall to replace the turbine with a gas-fired system however both organisations were awaiting the outcome of the review of the Federal CHP Law (KWK) which was expected to further incentivise Vattenfall to develop gas-CHP at Wedel. Following the confirmation of the CHP Law amendments Vattenfall announced in 2016 that it will invest €83.5m to upgrade Wedel and replace the coal plant with gas fired CHP (Vattenfall, 2016).

The remunicipalisation campaign started in 2008 when it became apparent that concession contracts to operate grid infrastructure were due for renegotiation. A number of environmental groups, led by BUND (German Friends of the Earth) developed the 'Unser Netz, Unser Hamburg - Our Hamburg, Our Networks' campaign and tried to engage the city senate in the remunicipalisation proposal. BUND, Robin Wood (an environmental NGO), church groups, Attac (an anti-

[96] Ironically Vattenfall sold its German coal operations and several coal fired power stations in Germany in 2016 as part of its strategy to shift towards renewable energy.

globalisation NGO) and the local consumer advice centre (Verbraucherzentrale) then worked together to mobilise support for the campaign, which was backed by the Greens in government. The Chamber of Commerce (including Vattenfall) developed a counter-campaign and the Senate initially opposed the buy-back on the grounds that it would be a poor financial investment.

In 2010 the Unser Netz, Unser Hamburg campaign approached the Senate with a petition requesting a referendum but the Senate requested a more extensive three step process to reach a referendum. This involved collecting 10,000 signatures within 6 months, then collecting 60,000 signatures within an additional 3 weeks, followed by the referendum in 2012 (interview 35-NGO). The final referendum in 2012 consisted of just two sentences demanding ‘the transition of the city’s grids into public ownership’ and to develop ‘socially just, climate compatible and democratically controlled energy provision from renewable sources’ and passed by a narrow margin with 50.9% of votes for remunicipalisation (Becker, Naumann and Moss, 2016).

6.2.3 Rhein Hünsruck

Rhine Hunsrück is a largely rural district with 102,000 inhabitants and the district has been working on energy issues for several years, starting with the development of energy efficiency programmes in 1999. Following this an Energy Concept was developed for the area in 2006 and an extensive number of renewable energy projects have been implemented since this date. The region generates more renewable electricity than it consumes with renewable electricity production in the region accounting for 177% of energy consumption (Fleck, 2015).

Local climate change discourses adopted a number of storylines relating to the environmental, economic and employment benefits of developing energy projects. In particular, financial and energy independence storylines were strongly represented in the local authority’s narratives which emphasises the potential to develop low carbon energy projects in order to retain energy spend in the local area (Fleck, 2015, interview 34-LA). In order to gain credibility for this argument a review of energy spend and flows within and outside of the region was commissioned which suggested that the region spent €280million per year on energy but that €250 million of this annual figure was spent on energy imports and left the region.

In the last ten years the district has developed several small heat networks in rural communities, most of which are fuelled by biomass. The initial impetus for the development of these networks was based around the regions 120 wood waste centres which provided the opportunity to source large quantities of wood chips at a low price. This led to the development of a number of schemes providing heat to a range of residential, commercial and public sector buildings. Additionally a number of small, village networks have been developed with 10 biomass heat networks in operation and seven in development in 2015 (Fleck, 2015). These village schemes tended to be driven by local residents and village mayors and operate as a mix of privatly owned co-operatives and schemes operated by the local utility, Energieversorgung Region Simmern. Energieversorgung Region Simmern is municipally owned subsidiary of the municipal water and sewage company and supports community heat networks schemes that request help. The local utility operates these schemes on a not-for-profit basis and develops different pricing structures for each village due to the different profile of each scheme (interview 33-LA).

Finance for heat networks has come from a variety of sources with direct contributions from communities via local cooperatives accounting for a significant proportion. Income from historic wind developments in the area was also important, particularly as the region was an early developer of community owned wind projects[97] so income built up from schemes could be used to fund heat networks and other energy schemes. An interviewee suggested that some villages have ‘5 or 10 wind turbines so 10x€30,000, they have €300,000 per year more than before so they say, ok let’s build a kindergarten for the school and we will build a heating grid – they have the money’ (interview 43-LA). This strong community ownership of wind turbines in the region differs from some other areas of Germany where a higher proportion of wind farms are owned by

[97] 95% of wind turbines are community owned in Rhine-Hünsruck (interviewee).

large landowners and farmers. A number of projects also received low cost loans from the KfW bank and the economics of projects was helped by most domestic properties being previously heated by oil.

The local authority presented their role as one of coordination and support and suggested that the presence of a small number of ‘pioneer’ villages had inspired other communities. This had led the local authority to develop processes for local knowledge sharing and mentoring, such as inviting village mayors to meet with villages with existing heat networks to hear their experiences of project development and operation. They also highlighted that momentum to decarbonise local energy systems had built up in many villages with several pursuing multiple sustainable energy projects, such as PV, biomass heat networks and thermal storage.

The relationship between the local authority and local communities was framed as a long-term partnership on multiple low carbon projects, which had enabled considerable trust to develop between actors. Although the city authority operated a local utility it expressed a preference for community ownership and only pursued projects via the local utility if a community expressed an interest in a scheme but did not have the capacity to develop it themselves. The local authority also aimed to take on a coordination role with other infrastructure, such as synchronising the installation of heat network pipes with superfast broadband and the undergrounding of electricity wires in some areas.

6.3 Policy discourse evolution

Although there has been some support for CHP and heat networks in German energy policy since the early 2000’s (see 2.6.2) until recently this was relatively limited and policy commitments have been largely focussed on electricity decarbonisation and efficiency. Additionally in a 2005 report commissioned by the Federal Ministry of Economics and Labour (BMWA) suggested that final energy consumption from heat networks would not increase to 2030 (EWI and Prognos, 2005). Notwithstanding this, since the adoption of the Integrated Energy and Climate Programme in 2007 successive German governments have put strong emphasis on heat networks and CHP. Indeed by 2011 the Federal

Ministry of Economics and Technology (now part of BMWi) were highlighting the importance of urban heat networks, suggesting that ‘municipal energy supply systems must be transformed into decentralised systems with a high level of combined heat and power generation and the flexibility to adapt to changing demand’ (BMWi, 2011: 29).

There is limited discussion of the barriers to heat networks in German energy policy documents, partly due to the established nature of many of the support schemes and the view that much heat network growth would take place in existing networks. In the past there had been recognition of financial barriers to networks but the development of pipework grants were seen to largely address this, particularly as grants have also more recently been made available through the CHP law for heat network storage systems. The limited references to barriers tended to focus on similar issues to in England, relating particularly to finance, complexity and regulation (Agora Energiewende, 2015b; Hamburg Institut Research GmbH, 2015).

Heat network policy does not have a high political profile nationally and there was an overwhelming focus on CHP policy. In particular a lack of awareness of the benefits of cogeneration was seen to impede more rapid growth in CHP-heat networks and changing energy system economics were making it more difficult to invest in large CHP-heat networks (CODE2 Cogeneration Observatory and Dissemination Europe, 2013). In this context barriers to growth focussed more on the need to move away from coal (and eventually gas) generation in order to contribute to the energy transition.

In common with England there was a recognition in policy that the development of heat networks would require long-term planning and oversizing of networks but the existing presence of many municipal utilities in either running networks or developing local energy concepts (spatial plans) was seen to limit this barrier.

Discussion of heat network regulation was not high profile, outside of specific enquiries by the Bundeskartellamt, although there were limited concerns regarding the lack of transparency of network pricing structures from some

NGOs and consultancies (Bundeskartellamt, 2012; Hamburg Institut Research GmbH, 2015). Table 11 outlines the key policy documents relating to heat networks in Germany from 2007 to 2017.

Table 11: Heat network policy and discourses in Germany

Year	Policy document	Heat network reference or wider narrative
2007	2007 Integrated Energy and Climate Programme	Aims to cut greenhouse emissions by 40 per cent to 2020 compared with 1990 levels. The programme focuses on energy efficiency and includes provision to further support CHP.
2008	Baden-Württemberg is the first state to establish a Renewable Heat Law making the installation of a percentage of renewable energy for heating compulsory in any renovation of existing residential buildings (Jörgensen, 2012).	No specifically heat network focussed but created precedent for state rules promoting low carbon heat
2009	Renewable Heat Act passed. Hamburg government establish Hamburg Energie	Target to increase the share of renewable heat to 14% by 2020. New building owners are required to source a proportion of heat from renewable energy systems[98]. Those who do not wish to use renewables can connect to a heat network, provided the heat is sourced from renewables, at least 50% CHP or waste heat (Energy Transition, 2012). The Act only applies to new buildings but make provision for individual German states to enact similar policies for the existing building stock (Schönberger and Reiche, 2016).

[98] The minimum percentage depends on the renewable energy technology used.

	Amended CHP law (KWK)	A Conservative-Green government in Hamburg decreed the establishment of a municipal utility (Hamburg Energie). (Becker, 2017) Includes an aim of 25% of electricity production from CHP (but no timescale stipulated). Subsidy support is available for all sizes of CHP and for both modernisation and new installations. Specific support for heat networks is also introduced, providing up to 20% of investment costs[99]. The total budget for the KWK was set at a maximum of €750 million per year, including a maximum of €150 million for new or expanding heat networks. The support is funded by consumers through a levy on the grid operators and if the €750 million limit is exceeded then installations over 10 MWe get proportionally less (Golbach, 2012).
2010	Government publishes 'Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply'	The document defines the future German energy system until the year 2050 (BMU and BMWI, 2010), committing Germany to reducing greenhouse gas emissions by 80% to 95% by 2050, and to producing 80% of the country's electricity from renewable sources by the same date (Richter, 2013)[100].
2011	Fukushima Daiichi nuclear ac cident and a decision to accelerate the phase-out of Germany's nuclear fleet to 2022 with the immediate closure of the eight oldest plants.	Whilst the main Energiewende decarbonisation commitments were made in 2010 the commitment to phase out nuclear had a major impact on energy policy. The Energiewende (energy transformation) was announced which aims to speed up the 'Energy Concept' to compensate for the nuclear

[99] Grants of up to 20% of investment costs were available if a network is supplied with at least 60% of heat from cogeneration and is in operation by 31 December 2020, up to a maximum of €5 million per project.
[100] The GHG reduction targets are to reduce emissions by 40% by 2020, 55% by 2030, 70% by 2040 and 80% to 95% by 2050, each relative to 1990.

		phase out (Schmidt, Jäger, & Karl, 2012; International Energy Agency, 2013)
	Research for an environmentally sound, reliable and affordable energy supply. 6th Energy Research Programme of the Federal Government (BMWi)	Highlights the importance of urban heat networks, suggesting that 'municipal energy supply systems must be transformed into decentralised systems with a high level of combined heat and power generation and the flexibility to adapt to changing demand' (BMWi, 2011: 29). Emphasises supporting 'municipalities, urban areas and communities to be carbon neutral by 2020' (BMWi, 2011, p. 97). Develops 'Energy Efficient Cities' (EnEff:Stadt) and 'Energy Efficient District Heating and Cooling Supply' (EnEff:Wärme) programmes to support urban projects including heat networks (BMWi, 2014).
	CHP law review	The CHP law review indicated that further policy support would be required to meet the target of 25% of electricity from cogeneration.
2012	CHP law amendment (KWKG)	KWKG amended to improve the incentives for investments in cogeneration plants and introduce a target of 25% of electricity from CHP by 2020. (CODE2 Cogeneration Observatory and Dissemination Europe, 2013; BMWi, 2015b)
		The scheme provides low cost loans to municipalities to plan, organize, and implement district-wide retrofit schemes

	German development bank, KfW, launch ‘Energetische Stadtquartiere’ (Energetic Neighbourhoods) Federal Cartel Office carried out a sector inquiry into het networks (Bundeskartellamt, 2012).	and to implement heat networks (Morris and Pehnt, 2012). Concerns expressed regarding the ‘intrinsic monopolistic’[101] structure of heat networks and local pricing. The inquiry Cartel Office found sufficient reason to suspect some prices were inflated, with some companies over charging.
2013	Hamburg energy remunicipalisation referendum successful Federal Cartel Office heat network investigation	The buy-back campaign was successful with a narrow majority of 50.9 per cent (Becker, 2017), adopting a slogan of ‘Our Hamburg, Our Networks’. The German Cartel Office further investigated heat network prices focussed on seven utilities where there were concerns regarding prices. The review was complex, accounting for the impact of varying generation and grid structures on prices, but led to Stadtwerke Leipzig GmbH agreeing with the Bundeskartellamt to lower its district heating prices by €8million per year over five years (Bundeskartellamt, 2015).
2015	Energy Efficiency Strategy for Buildings.	All scenarios indicate heat network emissions decrease by between 30-38% by 2020 (compared to 2008) and between 60-75% by 2050 (BMWi, 2015a). The Federal Government recognises the need for existing grids to transition to low carbon supply, highlighting the importance of developing

[101] The inquiry highlighted that once a customer connects to a heat network they are, in effect, limited to one monopoly supplier. In addition in some areas connection to and the use of the municipal district heating system may be compulsory, providing the district heating supplier with legally protected monopoly position.

		low temperature heat grids in order to utilise geothermal and other renewable sources of heat, as well as stored heat.
2016	CHP law amendment (BMWi, 2015b).	Amendments involved increases to the gas-fired CHP surcharge, the removal of coal-fired CHP plants from eligibility and a change in the CHP target. Heat network pipework eligible costs increased from 20% to 30% (for pipe diameters of over 100 mm) or 40% (for pipe diameters below 100 mm). Support is now also available for district cooling grids and thermal storage used in conjunction with CHP plants. Recognising the importance of heat networks and CHP in grid balancing, CHP electricity which is not fed into a public grid will no longer receive support[102] (CODE2 Cogeneration Observatory and Dissemination Europe, 2013; BMWi, 2015b).
2017	'District Heating Pilot Projects 4.0' launched (BMWi)	Support and funding launched for networks based on renewable energy. Under the pilot project funding is available not just for individual technologies or components, but for overall systems that rely on renewables for at least of 50% of the heat or cooling energy they deliver. Initially funding is available for feasibility studies (for up to 60% of costs). At a later stage there will also be capital funding for 4th generation heating network system (30 to 50 per cent of cost of the project).

[102] Exceptions apply to CHP plants below 50kW and CHP plants used in energy-intensive industries.

6.4 Problem definition and the role of heat networks

As discussed in chapter 5, problem definition discourses play an important role in shaping policy responses and the wider environment for action. In relation to heat networks in Germany the significant problem definition storylines can be summarised as 'heat policy neglect', 'multiple priorities and system flexibility' and the 'role of CHP'. This section discusses the development of these storylines and their role in shaping the discursive space for heat network policy development based on national and local interviews and analysis of documentary evidence.

6.4.1 Decarbonisation and heat policy neglect

Similar to the UK context, the decarbonisation of heat has tended to be a relatively neglected element of decarbonisation policy in Germany, with the Energiewende largely focussed on processes of electricity transition (Gailing and Röhring, no date). The German Energy Concept is explicitly based on twin core strategies of expanding renewable electricity and increasing energy efficiency and this has tended to limited space for debate of heat decarbonisation (BMU and BMWI, 2010). Recent progress has indicated that German policies to promote renewable electricity have been relatively successful[103] but that progress on energy efficiency is slow with primary energy consumption reducing by 7.6% between 2008 and 2015, against a target of a 20% reduction by 2020 (BMWi, 2015b). This has led to increased focus in policy documentation on measures to increase energy efficiency, for example through the publication of a National Action Plan on Energy Efficiency in 2014, an Energy Efficiency Strategy for Buildings in 2015 and a Green Paper on Energy Efficiency in 2016 (Federal Minstry for Economic Affairs and Energy, 2014; BMWi, 2015a, 2016)

Whilst there has been increasing focus on energy efficiency relatively limited attention has been paid to heat decarbonisation, partly as the expansion of renewable heating is perceived to be relatively successful with renewable heat accounting for 13.1% of final energy consumption for heating and cooling in

[103] Renewables accounted for 31.6% of gross electricity consumption in 2015 with a target of at least 35% by 2020 (BMWi, 2015b).

2015, against a target of 14% renewable heat by 2020. Government forecasts suggest that renewable energies are likely to account for 16.3% of energy consumption for heating and cooling by 2020 (BMWi, 2015b).

Despite the limited prominence given to heat in policy debates there is evidence that heat is slowly moving up the policy agenda, with increased reference to the need to decarbonise heat in policy documentation (BMUB, 2014), by industry and NGO actors (Deutsch Umwelthilfe, 2017) and from interviewees (interviews 30-TA, 32-A, 45-NGO, 46-C). This increased focus on heat decarbonisation was framed by interviewees as (1) a logical progression of decarbonisation policy as the focus moves on to more complex decarbonisation areas such as heat and transport, and (2) party driven by an increasing number of organisations becoming interested in low carbon heat due to reduced returns from renewable electricity projects following reforms to the EEG in 2014 and 2016 (interviews 30-TA, 32-A, 45-NGO).

This increasing focus on heat decarbonisation includes particular emphasis being put on the need to integrate the heat and electricity sectors[104] in order to promote system flexibility and integrate high shares of variable renewable electricity. In this respect heat networks[105] are receiving increased attention due to their ability to facilitate flexibility through the use of large scale heat pumps and storage (Agora Energiewende, 2015a; BMWi, 2016). In the shorter term gas-CHP heat networks were framed by a range of policy actors as able to ‘make an important contribution to reaching German climate goals’ (Agora Energiewende, 2015a; BMWi, 2015b). The role of CHP policy discourses is discussed in more detail later in this chapter (sections 6.4.3 and 6.5.1).

Despite some increase in the policy profile of heat decarbonisation interviewees suggested that the political and policy focus was on high profile electricity system issues such as the need to reduce coal use and address the costs of renewable electricity policies. Although there is some local experimentation with

[104] Referred to as ‘sector coupling’ by the BMWi.
[105] Heat networks are generally referred to as district heating or heating grids in German policy and industry literature but for consistency they are referred to as heat networks throughout this document.

low carbon heat one interviewee suggests that ‘other than that the heat issue is not on the agenda really in Germany, everyone is dealing with lignite coal and heating so far is disregarded’ (interview 46-C). In this context new policies interrelating with heat tend to be focussed on reducing heat demand (through energy efficiency) or electricity (such as CHP or the electrification of heating). The policy debates relating to heat networks specifically tended to focus on the decarbonisation of existing networks, facilitating their role in system flexibility[106] and increasing connection density in areas of existing networks, rather than on extensive development of new networks (Prognos 2015; BMWi 2015a, interviews 32-A, 38-TA, 45-NGO).

Interviewees also suggested that it was difficult to develop heat policy, and particularly heat network policy, due to the configuration of German institutional structures. Heat networks were described as not having a focus within the organisation structure of the Federal Ministry for Economic Affairs and Energy, particularly as there were staff focussed on both CHP and renewables but ‘no district heating people’ (interview 36-G). This was corroborated by another interviewee who suggested that

> ‘at the Ministry it [heat network policy] is a little bit everywhere and nowhere at the same time. It overlaps with the CHP people and the renewable people but I don’t think there are heat network people’ (interview 46-C).

6.4.2 Multiple priorities and system flexibility

As discussed in chapter 5 there was a strong theme in policy debates in England relating to the ability of heat networks to meet multiple priorities, including fuel poverty concerns, economic regeneration and carbon emissions. Although there was some reference to the ability of heat networks to meet multiple priorities by German interviewees (interviews 31-LA, 39-TA, 45-NGO) this tended to focus on carbon reduction and local economy priorities with little reference to energy poverty. This is likely to be partly due to the lower political and public profile of energy poverty in Germany (Becker, Kouschil and

[106] For example through heat stores.

Naumann, 2014). However energy costs are becoming increasingly politicised in Germany due to rising domestic energy costs being linked to the Energiewende and specifically subsidies for renewables, with annual EEG surcharge costs of €23bn in 2014 (Kuzemko *et al.*, 2017). There has already been a policy response to this issue with reforms to the KWKG in 2014 and 2016 which set a framework for fewer exemptions from EEG surcharges and measures to slow down the growth of renewables[107].

In contrast significant focus was put on the ability of heat networks to contribute to a range of energy system objectives. This was a common theme across interviewees and policy documentation with both emphasising the changing structure and economics of the energy sector and the potential for heat networks to contribute to challenges relating to electricity and heat coupling and system flexibility (interviews 31-LA, 34-MU, 45-NGO). As one interviewee stated:

> 'We don't have a problem in the electricity sector, we will have an electricity sector with above 100% renewables at some hours so we rather have a problem of consuming electricity at the right time and district heating networks could provide that flexibility' (interview 41-C).

This framing of heat networks as playing an important role in long-term decarbonisation and system flexibility did not however translate into calls for more support for heat networks specifically. Both national and local interviewees tended to instead focus on the need to support gas-CHP and the integration of renewables into existing heat networks. This was reflected in government reports which give limited profile the development of new heat networks but forecast extensive switching to gas-CHP and renewable heat in existing networks (BMWi, 2015a). This includes a focus on the importance of

[107] Including the introduction of auction rules for new medium and large-scale renewable generation.

low temperature heat grids[108] in the future in order to utilise heat from geothermal and other renewable sources as well as stored heat.

In Frankfurt heat network narratives in the city emphasised how heat networks can support ambitious climate targets and the development of a ‘local’ and ‘flexible’ energy mix (interviews 31-LA, 35-NGO, 53-MU). This tended to background the role of fossil fuels in the city’s current networks, although coal and gas account for a significant proportion of heat generation. Instead the wider system benefits of heat networks were emphasised, highlighting the potential for heat networks to facilitate interactions between the electricity and heat systems. This was exemplified by recent projects which include the installation of a power to heat system which shifts from electricity production to directly supplying heat to the network at times of low electricity prices and a power to gas[109] pilot, although this is not yet directly connected to the heat network.

While both Hamburg and Rhine Hunsrück placed strong emphasis on the need to develop low carbon networks they made less reference to their ability to support wider energy system flexibility, although both were developing storage projects to enable better integration of the heat and electricity sectors. Instead, in Hamburg, the problem framing relating to heat networks was dominated by the need to remunicipalise the heat networks in order to more rapidly move away from coal generation. Similarly in Rhine Hunsrück, there was a joint focus on heat networks reducing carbon emissions and enabling the retention of energy spend in the local area (Fleck, 2015, interview 43-LA). This led to a storyline of taking action on sustainable energy in order to localise benefits from energy spend and create ‘regional added value’ in the form of jobs and economic activity.

[108] These systems are referred to as 4th generation district heating.
[109] The pilot uses cheap electricity to generate hydrogen which is directly fed into the natural gas grid. The hydrogen could also be used to fuel the gas CHP plant on the heat network.

6.4.3 The role of CHP

In addition to a gradual increase in focus on heat decarbonisation, energy policy discourses in Germany are assigning a prominent role to CHP with the 2014 Climate Action Programme suggesting that electricity emissions will be reduced through a combination of the expansion of renewable energy, the modernisation of existing fossil fuel power stations and the development of combined heat and power (BMUB, 2014). CHP is described as able to play a role in climate protection, supply security and efficiency in the electricity sector (Agora Energiewende, 2015b). The benefits of CHP are, however, largely framed in terms of electricity sector benefits - such as the integration of high shares of renewable electricity, system flexibility and efficiency - rather than specifically their potential to decarbonise heat, although the majority of CHP is integrated with heat networks (BMWi, 2015b).

In relation to heat network policy the need to support CHP tended to dominate debate (interviews 35-NGO, 39-TA, 40-LA, 46-C, 38-TA, 52-G, 53-MU). The most common reasons identified for this were the need to replace current coal-fired CHP plants and the poor economics of gas-CHP with interviewees suggesting that 'right now it's just not economically viable to build CHP plants' (interview 30-TA). This was mainly attributed to increasing penetrations of renewable electricity reducing wholesale electricity costs and therefore reducing the revenues made from the electricity generation element of CHP, which is where schemes tend to make the majority of their profits. CHP is therefore framed as both a useful tool in decarbonisation and a 'victim' of the success of electricity system decarbonisation to date.

The characterisation of CHP as playing a role of the Energiewende was well established in policy with the CHP Act explicitly formulating 'the heating sector and CHP as a climate protection technology' (interview 30-TA). Additionally gas-CHP was framed as an important route to replace coal generation and developments to the CHP Act (KWK) were highlighted as partly in response to the desire to phase out coal-fired heat networks.

However the role of CHP is also contested with some analysts and NGOs suggesting that support should prioritise low and zero carbon energy sources which are compatible with heat networks (such as geothermal, solar thermal, industrial waste heat) rather than gas-CHP (interviews 41-C, 46-C). Other interviewees suggested that the role of gas-CHP heat networks in system flexibility is complex as CHP plants need to run in winter to deliver heat, and this would result in electricity also being generated at the same time as periods of high renewable electricity generation from wind farms. Although some of these issues could be dealt with through storing electricity and heat this is likely to still be problematic (interview 52-G).

Notwithstanding some local contestation of the role of fossil-fuelled CHP, the construction of gas-CHP as an essential area for policy support in order to facilitate longer-term decarbonisation appears to have been relatively successful. This includes an industry representative suggested that they

> 'had to explain [to policymakers] why we feel CHP has to play a role in any kind of decarbonisation because they didn't really know or didn't have a focus but we're step by step moving forward in the discussion' (interview 30-TA).

This was reinforced by policy actors in Government suggesting that 'given the life of infrastructure there's room for one generation of CHP at least' (interviews 36-G). Although they highlight that the 'real problems with system integration are still to come'.

This section highlights how problem discourses relating to heat networks have largely been framed as about the need to support gas-CHP systems in the short-term however the options to support CHP was an area of significant debate and is returned to in the following section on emerging and established discourses.

6.4.4 Regulation and heat prices

An additional policy area which some actors were attempting to present as an important problem in relation to heat networks related to heat pricing. This was an area of significant divergence between actor groups with consumer groups and NGOs highlighting issues relating to heat network pricing while industry, local authorities and government made limited reference to the issue.

One interviewee suggested that heat pricing was not transparent and varied a great deal across the country as

> 'the heat companies don't publish necessarily their prices, they basically say if you want to have district heat give us a call and we'll make you an offer. It's totally intransparent…is that the price they offer to everyone, do they make a special deal with certain customers, does it depend on how good you bargain with them?' (interview 46-C).

Additionally heat tariffs in stadtwerke were described as a 'political issue' with some local authorities seeking to influence the stadtwerke to set low heat prices while other municipalities with established networks with cheap coal generation, were described as using heat networks as a 'cash cow' (interview 46-C). State-based Consumer Associations, which are funded by both the Federal government and the Länder to provide advice, information, political representation and lead legal challenges on the behalf of consumers, are increasingly active in this area with the Hamburg Consumer Association both supporting the energy remunicipalisation campaign and successfully filing a collective legal challenge against Vattenfall in relation to the transparency of their pricing structures. Hamburg Consumer Association highlighted that they had to develop new competencies in the area of heat networks which due to the high political and public profile of energy issues in Hamburg they were able to resource. However they also suggested that it is unlikely that many other local consumer associations would be able to engage in local energy issues to the same degree (interview 50-NGO).

These concerns were also articulated by some consumer groups and NGOs in relation to current arrangements for national price oversight. As discussed in chapter 2 there is currently ex-post regulation of heat networks prices in the form of oversight by the Anti-Trust Authority (Bundeskartellamt). This means that the Bundeskartellamt periodically reviews pricing structures in the areas of highest prices and can instruct network companies to reduce prices. A number of interviewees expressed concern that this is an ineffective method of price oversight as it only addresses the areas with the very highest prices and there are difficulties in comparing prices across regions due to differing infrastructure costs and historic factors leading to widely differing costs to operate networks (interviews 30-TA, 46-C, 49-G). Additionally the role of the Bundeskartellamt was described as ‘very weak because they carry the burden of proof and they have to prove the prices of the utilities are too high which is very hard’ (interview 46). There is the potential for local Anti-Trust Agencies (Landeskartellbehörden) to carry out enquiries into heat network prices but interviewees suggested that Landeskartellbehörden tend not to have the resources or staff to carry out these detailed investigations.

The issue of variation in heat pricing was not adopted as a key problem at the national level with very limited reference to heat prices in policy documents or by policy actors. Instead industry actors highlighted that the Government requires various heat pricing standards in the ‘Regulations on General Conditions for the Supply of District Heating (VBFernwärmeV)’ and through the extensive technical standards and codes of practice developed by the AGFW. An interviewee also noted that the Bundeskartellamt had evaluated the poential to adopt ex-ante approval of heat network prices but had determined that this would increase consumer costs (interview 39-TA).

In general the theme of consumer protection, both in terms of monopoly supply and pricing, while promoted by a number of consumer and NGO actors, was not successful in establishing as a significant ‘problem’ in relation to heat networks. There was little reference to heat pricing in the case studies, although it was raised by consumer groups and NGOs in Hamburg. This is likely to be due to the increased engagement of consumer groups and NGOs in energy issues over the course of the Hamburg remunicipalisation which appears to have both upskilled these groups in order to engage in debates on energy policy more fully.

The low profile of heat network pricing debates may also relate to trends in housing tenure in Germany. Multiple occupancy housing (i.e. small apartment blocks) are common in Germany cities and are often owned by housing companies who negotiate heating supply and pricing directly with energy companies and include energy costs in rents. This gives little visibility of heating costs to householders. Some interviewees argued that this arrangement enables the housing companies to achieve better prices as they are familiar with negotiating contracts, however another interview suggested that ‘housing associations don’t care about energy costs as it’s only a small part of the total rental cost they charge’ (interviews 32-A, 46-C).

6.5 Established and emerging discourses

This section presents the key established and emerging discourses evident in analysis of policy documents and interviews at the national and local level. It suggests that while discourses relating to the need to support CHP and the role of municipalities in heat networks are well established there is a more contested storyline in relation to the remunicipalisation of energy services.

6.5.1 Supporting CHP

As discussed in section 6.4.3, a storyline regarding the need for short-term support for gas-CHP as (1) a route to minimising coal generation and (2) to enable the longer-term integration of low and zero carbon technologies, successfully resonated with the current policy and political climate in Germany. This relates particularly to discourses regarding the need to further progress the Energiewende whilst minimising costs to consumers as the cost of the Combined Heat and Power Act (KWK) was widely described as ‘insignificant when compared with the cost of renewables’ (interview 39-TA). Additionally CHP was partly framed as a ‘victim’ of the Energiewende as the growth of zero marginal cost renewables have resulted in low wholesale electricity prices and reduced profits from CHP plants, which are largely dependent on revenue from electricity sales. This led to far more focus on interlinkages between electricity and heat and the identification of other ways to utilise electricity during period of excess supply. These uses include power to heat applications which incorporate heat pumps (particularly with storage), low temperature heat generation through deployment of industrial electric boilers and the development of CHP-heat networks systems which cost effectively switch between heat only, electricity only and CHP production (Lehr, Kondziella and Bruckner, 2014; Hers *et al.*, 2015).

Although not all interviewees agreed that there should be more support for CHP there was acceptance that 'the whole business model is falling apart for CHP' and that 'the viability of gas-CHP is entirely based on electricity propping up heat and there's not much thinking about how the model works when you don't want the electricity' (interview 41-C).

Interviewees consistently suggested that the comparatively low cost of support for CHP, combined with emphasis on the role of CHP in minimising emissions in the short-term had resulted in widespread support for the extension of the KWK. Even proponents of prioritising renewable heat and storage over gas-CHP acknowledged that this is a 'non-mainstream' position (interview 46-C) and that the need to support gas-CHP had largely been accepted by the policy community. Indeed the BMWi highlights that 'CHP plants – particularly those using low-carbon fuels – make an important contribution to reaching German climate goals' and suggests that the amendment to the KWK in 2015 'sets the stage in many important areas' providing 'incentive for investment in highly efficient, flexible, low-carbon CHP plants' largely replacing coal plants (BMWi, 2015b). Data indicates that the 2015 amendments are having a positive effect on CHP deployment with an increase in electricity generated from CHP between 2015 and 2016 (Federal Environment Office, 2017).

Whilst these debates made reference to the links between gas-CHP and heat networks the focus was particularly on supporting CHP rather than on the need for further policy support for network infrastructure (pipework) or storage as support for these elements of heat networks was largely deemed to be sufficient. This resulted in limited active policy development in relation to heat networks, over the maintenance of existing grants and the extension of the KWK. However there was clear rhetoric from government regarding the importance of heat networks in long-term system transition and support for CHP was contextualised as time-limited as the Energiewende progressed (interview 36-G). More broadly the national CHP target, which has been in place since 2009, was seen as clear Government support to grow CHP-heat networks (interviews 35-NGO, 39-TA, 40-LA, 46-C). Conversely the amendment to this target in 2016, which effectively made the 2020 target easier to achieve (see chapter 2), was not described by interviewees as a roll back on support for CHP or heat networks and instead tended to be framed as a practical measure to recognise that growth of CHP is likely to take place at a 'moderate pace' (BMWi, 2015b).

Interviewees in both Hamburg and Frankfurt highlighted the importance of further support for gas CHP in their heat network development plans and framed gas-CHP as a transitional arrangements to enable their networks to move away from coal generation, with a longer-term focus on low and zero carbon forms of heat generation such as geothermal, heat pumps and waste. In contrast Rhein Hünsruck were focussed exclusively on renewably fuelled heat networks and did not refer to support schemes for gas-CHP. Instead they emphasised the importance of policy to support biomass and storage.

Overall interviewees tended to suggest that the policy framework for heat networks, in the form of pipework grants, storage grants and support for municipal energy planning, was fairly strong but that increased focus was needed on the economics of gas-CHP and longer term integration issues (interviews 43-LA, 45-NGO, 46-C, 41-C, 53-MU). An interviewee summarised it as;

> 'we've got a system in Germany that supports CHP but we need to improve that…but for heat networks, not CHP but heat networks, I don't think there's much need for improvement…you get support and you can get up to €5million for a project now. €100 per metre for smaller pipes less than 100mm, 40% of the costs. So it's already not that bad. The only thing is that there is a cap at €5 million for each project so we are advocating for that cap to be raised up to €10 million' (interview 30-TA).

The cost of the CHP tariff, together with grants for heat network pipework and storage was also described as 'very small compared with the cost of renewables, heat networks is something like €6-7 per year [on consumer bills], almost nothing' (interview 39-TA). As such these support schemes were described as quite 'safe' from political change (interview 47-MU).

This approach of highlighting the long-term benefits of heat networks (and CHP) for both heat and electricity decarbonisation and the relatively low costs of current support measures illustrates how advocates are adopting storylines with strong cognitive appeal for policymakers. In relation to problem definitions, despite the framing of heat networks as an enabler of system flexibility, there was also evidence of heat networks as sites of conflict and contestation in relation to the Energiewende. In particular the reliance of many heat networks on fossil fuels[110], and particularly coal, was framed by some interviewees as putting heat networks in opposition to the Energiewende (interviews 32-A, 46-C, 53-MU). For example, although government policy recognises the need for heat networks to transition away from coal, the shift to gas-CHP was largely framed as a 'solution' to this, at least in the short- to medium-term (interviews 36).

6.5.2 The role of municipalities

In terms of established, and generally uncontested, narratives there was widespread characterisation of local authorities as established actors in the energy system, and particularly heat networks. As well as in the practical sense that local government own and operate substantial energy undertakings this was also framed as an influencing role with local government playing important role in raising heat networks (and CHP) up the national government's agenda (interview 30-TA). Although both industry actors and local authorities suggested that they had been closely involved in consultation on the amendments to the CHP Act the BMWi and industry associations suggested that stadtwerke were particularly influential as they tend to have close links to policymakers due to

[110] A policy interviewee suggested that currently approximately 60% of networks are fuelled by gas and 15% by coal (interview 36).

the historically close relationship between the Social Democratic Party and some municipal governments (interview 36-G).

A strong role for municipalities in energy governance was also reflected in national policy documents with cities and municipalities often referred to as key agents in system transformation (BMU and BMWI, 2010; BMUB, 2014). The BMWi (2011, p.29) also suggest that 'municipal energy supply systems must be transformed into decentralised systems with a high level of combined heat and power generation and the flexibility to adapt to changing demand'. The complexity of urban energy transitions is recognised and the Government highlights that they are characterised by 'diverse energy supply structures, multi-dimensional ownership structures and the associated and various interests of numerous decision-makers and stakeholders' (BMWi, 2011, p. 29). As discussed in chapter 2 the importance of local governments in the energy transition was also embedded through a number of research and grant programmes such as 'Energy Efficient Cities' and 'Energy Efficient District Heating and Cooling Supply'.

Whilst these examples illustrate an established role for municipalities in the energy transition, a number of emerging storylines were evident which suggest that conceptualisations of the role of municipalities are complex and still developing. Firstly, there was a strong storyline relating to the 'professionalism' of stadtwerke. Several interviewees recognised that historically stadtwerke had not been seen to be efficient organisations as there had been a tendency for them to be inefficient and 'politically dominated' with local politicians nearing retirement often being appointed to senior positions (interview 30-TA, 45-NGO). However;

> 'there have been changes in managerial culture and they have professionalised a lot and now some of the local utilities are really working better than many private companies and they have very good management' (interview 30-TA).

In Frankfurt, Mainova had a clear identity as separate from, but influenced by, the local authority and was considered to be both professional and successful.

In contrast Hamburg Energie and the public entity being established to manage the remunicipalised heat network were portrayed as a break from mainstream energy actors (interviews 32-A, 40-LA). Whilst they again were described as professional and effective, framing them as a 'new' way of managing energy locally resonated with the considerable distrust that had developed in relation to Vattenfall and other traditional energy actors.

In Frankfurt interactions between the local authority and Mainova were largely presented as unproblematic by local authority actors, however the stadtwerke highlighted the difficulties in managing tensions between multiple local authority aspirations (interviews 31-LA, 39-TA, 53-MU). Potential conflicts between municipalities and their stadtwerke were also cited by some national organisations who referred to examples where local governments had high profile commitments to carbon reduction but also operated profitable coal-fired generation plants through their stadtwerke. Another interviewee suggested that many municipalities rely 'on the dividends from their companies so have an interest acting for the common good in the operational working of the company but other the hand they want to maximise profits as well, so it's an inner conflict of public ownership' (Interview 30-TA). Similarly another stadtwerke interviewee suggested that they 'are not driven by the city and their climate aims. We are driven by the market, so it's nice to see the aims and discuss them but the decision is made by the company' (interview 53-MU).

These conflicts demonstrated the importance of local politics in shaping the environment for heat network development with the political make-up of city governments identified as an important enabler for a long-term commitment to low carbon heat networks in both Hamburg and Frankfurt. Interviewees suggested that in many of the large cities people connected to the Green Party are promoting energy remunicipalisations but that the CDU is also popularising remunicipalisations with more conservative groups on the basis that it is good for regional economies (interview 45-NGO). Additionally broader local politics was also revealed to be important in Hamburg where a history of engagement in energy-based conflicts meant a wide coalition of actors was willing to engage in debates relating to remunicipalisation and the development of heat networks.

In Rhein Hünsruck the history of the region as a relatively self-sufficient rural district meant that a storyline of energy independence resonated particularly well.

Municipal involvement was also framed as important in enabling investment in heat networks as ‘municipalities are considered as very good lenders. Very low risk lenders. Traditionally they can’t really collapse, there is no bankruptcy law for municipalities so whenever there is an economic problem there will be a solution, mostly at the Federal state level’ (interview 32-A). This was seen to support municipal energy companies as they can ‘get very good rates because it’s basically state guaranteed so you have an advantage as a municipal company, a clear advantage over big private companies. Interest rates are simply lower’ (interview 30-TA). In addition both Frankfurt and Rhein Hünsruck referred to the importance of low cost loans from the KfW state bank.

6.5.3 Remunicipalisation

Notwithstanding the tensions identified in the municipal utility role in the previous section there was also a significant storyline relating to an increase in local authorities buying back infrastructure and grids and/or setting up new public utilities. Energy system remunicipalisation was linked to a number of practical investment factors such as local authorities being able to accept low rates of return, invest in long-term projects, and access cheaper finance[111] (interviews 31-LA, 34-MU, 39-TA, 46-C). However there was also repeated reference to a perceived failure of privatisation to deliver expected efficiencies and customer service. As one interview put it; ‘there is now some disillusion in the hopes of privatisation. It was always talked about as being more efficient, a better service, and people now realise that that’s not the case’ (interview 30-TA).

In this context heat, electricity and gas networks, already commonly publically owned in Germany, were referred to as ‘monopolies used for the public good’ (interview 50-NGO). This was particularly strong in relation to heat network

[111] Several interviewees referenced to the importance of KfW programmes that support local government and stadtwerke investment in sustainable energy.

development as local public utilities were characterised as more likely to have strong consumer protection arrangements and be able to take a long-term development view (interviews 30-TA, 34-MU, 41-C, 50-NGO). Other interviewees highlighted the generally good reputation of public utilities suggesting ‘they are just closer to the customer and regarded as very trustworthy’ and emphasised the importance of democratic control (interviews 30-TA, 35-NGO). Others suggested that the growth of stadtwerke coincided with a broader public sentiment that energy system ‘profits should be reinvested in Germany and city ownership allows this’ (interview 30-TA).

An additional storyline linked municipal ownership of heat networks to a wider move towards more collective forms of energy provision in Germany. The scale of cooperative ownership of renewable energy in Germany has been well documented (Nolden, 2013) but a small number of interviewees suggested the collective, monopoly nature of heat networks made it particularly suitable to public ownership and position it as part of a wider trend towards more collective forms of provision, including the growth in the ‘sharing economy’ (interviews 43-LA, 45-NGO, 50-NGO).

Although the diverse nature of public utilities was acknowledged several interviewees suggested that they all operate with a common commitment to the public good; so while there are

> ‘utilities that have got 10 people working for them, and then you’ve got the Stadtwerke in Munich which has a turn-over of some €8 billion per year. It’s a huge company and so obviously they are different but they still have got something in common, it’s public ownership and working for the public good, and that links together companies of very different sizes. It’s really interesting to see’ (interview 30-TA).

These themes of the failure of privatisation and the need to maintain accountability in the provision of monopoly infrastructure (specifically energy networks) resonate with the work of Becker et al. (2017, p.78) who, in their study of energy provision in Berlin and Hamburg, suggest that energy remunicipalisations can challenging ‘the character of private infrastructure provision’ through the transformation of energy provision from a commodity to a public good, thereby providing an alternative to neoliberal urbanism. Similarly Fuchs & Hinderer (2014) link the resurgence of the role of local governments in energy, and other sectors, to a broader roll-back of ‘New Public Management’ approaches to governance. This suggests that long-term debates relating to governance more broadly can be influential in shaping local approaches to energy.

However a minority of interviews contested the public good objectives of municipalities with one interviewee suggesting that ‘we’ve seen so many municipal companies ripping off their customers that I’m a little bit disillusioned about the idea that they want to do anything good for the customers. They have shareholders, which is the city, and the city wants to have the money and they want to do whatever the political preferences of the city are. If you have a city that has a political preference on the environment then they might say to the utility then invest this money in enlarging the heat network system and invest in renewable energies, but if you have a political majority that wants to build more kindergartens and schools then they’ll just take the money and will not make the environment or the heat network customers benefit from it’ (interview 46-C).

The case studies supported this complex local relationship between municipalities and the energy system. In Frankfurt the local authority tended to present the relationship between the city administration and the local utility as unproblematic with the city using its political influence to shape the priorities of the utility, for instance by encouraging Mainova to change their pricing structure to reduce the heat network standing charge in order to promote energy efficiency. However, despite owning over 75% of the company the city government suggested that their influence is ‘minor’ and only enacted through a limited number of seats on the Board of Directors. As one interviewee put it ‘we can give them ideas but whether they follow these ideas or not is up to them’ (interview 31-LA). Mainova supported this portrayal of the influence of the city as limited but suggested that this was due to the need for the company to operate independently in order to generate profits for the city. The financial dimension of the relationship between the city and the utility tended to be backgrounded by the city but foregrounded by Mainova who emphasised the difficulty in balancing financial and non-financial objectives.

In Hamburg ongoing and multifaceted energy conflicts were deeply linked to different political and economic interests with the remunicipalisation campaign, across electricity, gas and heat, framed as a route to address long-term disaffection with energy system incumbents and the use of coal in the city.

6.5.3.1 (Re)politicisation

While there is a long history of municipal involvement in the energy system in Germany there was also evidence of a repoliticisation of energy with the remunicipalisation agenda being utilised by a range of political interests. As discussed in 6.5.2, interviewees suggested that both the Green Party and the CDU were promoting remunicipalisation in some cities, albeit for differing environmental and regional economy rationales (interview 45-NGO). The political make-up in both Hamburg and Frankfurt was highlighted as important in facilitating a stronger role for the municipalities in heat networks, with the Green Party being influential in both cases. In Frankfurt the Green Party played an important role in governing coalitions for many years and interviewees suggested that this helped to embed a long-term focus on sustainable energy planning and create a supportive environment for low carbon heat networks (interviews 31-LA, 34-MU).

In Hamburg the Moorburg plant was initially approved when the CDU was in power but the subsequent inclusion of the Green Party in a coalition government influenced the local authority's later position on the plant. Additionally, when the SDP was in overall control, the city bought back a 25.1% stake in the heat network but did not want a referendum. The SDP party, although supportive of the Energiewende, also have a strong political base in the former industrial areas in North Rhine Westphalia and close links with the Big 4 utilities, leading them to support the energy transition but at the same time try to protect their support base in the 'old system' (interviewees 32-A, 37-A). In Hamburg this included the Mayor of Hamburg, Olaf Scholz opposing the referendum campaign on the basis that it would add to the city's debts and several interviewees suggesting that Vattenfall had a close relationship with city elites which resulted in the city initially resisting the civil society campaign to remunicipalise. One interviewee suggested that 'Vattenfall and the Hamburg state, under Social Democratic rule, were so intertwined that the city just accepted the conditions [relating to Moorburg] and Vattenfall was smart in getting things through' (interview 41-C). In contrast the Green Party had close links to a range of civil society groups which then became involved in the remunicipalisation campaign. There was also a history of civil society groups coming into conflict with Vattenfall through both the development of Moorburg and heat network pricing (interview 50-NGO).

As Fuchs & Hinderer (2014) suggest if 'local authorities want to buy back the [grid] concessions, cancel the concessions, or revoke them, they usually face heavy resistance from the incumbent actors…The network operators, very often, are linked to specific political actors in the community, which immediately politicizes the conflict'. In Hamburg the remunicipalisation campaign also developed in the context of historic energy-related conflicts which had already engaged a wide range of environmental, social and religious organisations in relation to energy issues. This resulted in the use of a local referendum as a political tool to further mobilise a range of actors in energy infrastructure. Overall, these factors indicate the extent to which questions of energy infrastructure and supply have been politicised in the city.

The engagement of the community groups and civil society does not however suggest that the citizen's movement is never in opposition to the municipal movement and some NGO interviewees saw energy remunicipalisations as just another route to cities and states gaining more power instead of decentralising power to citizens. The Rhein Hünsruck case was an interesting opposition to this where interviewees consistently saw the municipality and cooperative movement as supporting each other in the Energiewende (interviews 33-LA, 43-LA).

6.5.4 Rural heat networks

An emerging discourse that was evident amongst NGOs and in Rhein Hünsruck, but not extensively in national debates, relates to the role of community-owned and rural heat networks. Much national policy rhetoric focussed on the likely growth in heat networks being in urban areas (BMWi, 2015a) and there was little reference by industry associations to rural networks. However a minority of interviewees suggested that there interest from rural communities in developing small, community owned and renewable heat networks was increasing (interviews 43-LA, 44-LA, 45-NGO, 46-C).

The importance of rural heat networks was linked to the growth of 'bioenergy villages' in Germany[112] where increasing numbers of rural settlements are seeking to meet their entire demand for electricity and heat from local renewable energy sources, particularly biomass and biogas (Jenssen, König and Eltrop, 2014). The first bio-energy village was Jühnde in 2006 and there are now over 212 bio-energy villages in Germany (Eichler, 2016). Although the Federal government has become increasingly interested in the concept, funding some projects and launching a national bio-energy villages awards scheme in 2012, this activity is led by the Federal Ministry of Agriculture with benefits largely linked to supporting rural economies. The national policy actors interviewed did not refer to the role of rural heat networks and discussions focussed instead on the growth of existing networks in urban areas. This suggests that the joint discourses of a need to support gas-CHP and the importance of stadtwerke have dominated heat network discourses and, whether overtly or indirectly, marginalised rural heat network discourses.

6.6 Key events and windows of opportunity

In contrast to England where a number of events and face-to-face interactions were important in developing relationships between actors and creating common understandings of issues, there were limited reference to the role of events and windows of opportunity in shaping heat network development in Germany. To some extent this may reflect the more developed nature of heat networks in Germany where local actor groups have more agency to develop

[112] And beyond, in Austria for example.

networks or to initiate pilot projects. Additionally, as discussed, the Energiewende was from the outset framed as a societal project which would require the involvement of a wide range of actors and technologies at different scales, resulting in a policy environment that supports a wide range of decarbonisation activity.

An exception to this was the current expiry of many grid concession agreements relating to heat, gas and electricity networks. In Germany grid concessions are given for around 20 years and following liberalisation in the 1990s many are now due for the first time since liberalisation (32-A, 35-NGO, 45-NGO). The expiry of grid concessions, together with an increase in distrust of privatised energy infrastructure models was described as creating a window of opportunity;

> ‘Following the liberalisation in the 1990’s 20 years on we’ve now got the expiring concession agreements and there is a general, a lot of people, mistrust the big private companies, especially the energy companies so that explains why people are thinking maybe it’s not a bad thing to have the grids back in municipal hands’ (interview 35-NGO).

Regardless of whether these concessions are renegotiated or remunicipalised the politicised nature of energy system development means that these contracts tend to be areas of negotiation and potential conflict as multiple interests seek to influence the future of energy infrastructure in a local area (Becker, Naumann and Moss, 2016). Clearly incumbent actors tend to resist efforts to remunicipalise networks. This is exemplified by the Hamburg case where Vattenfall sought to mobilise a coalition of economic and political actors to oppose the referendum and also, according to interviewees on the opposing side, withheld data and controlled information regarding the costs of the buy back. The expiry of concession contracts for heat networks therefore represents both a window of opportunity for consideration of public ownership structures and a politicisation of the provision of city infrastructure.

6.7 Coalitions and actor networks

This section explores how heat network discourses are being structured in Germany through their use by formal and informal coalitions and how various key groups are acting to coordinate storylines. It identifies three important themes relating to (1) the diversity and range of actors involved, (2) the type and role of industry associations and (3) the relative lack of emphasis put on the role of individuals in heat networks in Germany.

6.7.1 Diverse actors and civil society

As discussed in chapter 5 diverse actor networks tend to be involved in heat network projects due to the locally distinctive nature of each project and the need to involve a range of generation owners, heat customers, technical experts, investors and local decision makers. This was also the case in Germany however there was more evidence of a wide range of actors being involved through a diversity of ownership structures, and of better integration of a range of subnational actors into energy policy debates. This included interviewees suggesting that 'political influence is high for municipalities' and that diverse interests were represented by the main industry associations (AGFW, VKU and BDEW), as discussed in the next section (interview 36-G). Despite this influence on national policy was also described as dominated by large private utilities, stadtwerke and industry associations, with limited influence for civil society and community groups (interviews 30-TA, 43-LA, 45-NGO).

In contrast, at the local scale, civil society actors tended to play an important role in shaping approaches to heat networks, and decarbonisation more generally. In Hamburg in particular environmental, social and faith based groups worked together on the remunicipalisation campaign and were seen to play a long-term role in negotiating energy based conflicts in the city. Similarly in Rhein Hünsruck local community groups, largely based in individual villages, worked collaboratively with the local authority and stadtwerke to develop heat networks with a strong focus on local control of infrastructure. More broadly interviews characterised the agency and membership of local actor groups as shaped by historic institutional structures such as the relationships between the municipal authority, private sector, citizens and interest groups. For example, in Frankfurt the municipal authority had a long established energy department which had developed various advisory and planning functions which enabled it to act as a coordination body between the city's climate aspirations, private developers and housing corporations. Likewise in Hamburg the long history of a range of civil society actors engaging in energy debates meant they were well-placed to work together on energy network remunicipalisation (interviews 31-LA, 32-A, 45-NGO, 46-C).

Several city actors also made reference to the importance of transnational municipal networks (TMNs)[113] in supporting the development of low carbon heat networks, making reference to membership of the Climate Alliance of European Cities, the Covenant of Mayors, Energy Cities and the German Association of Cities and Towns. In Frankfurt the city highlighting the importance of these networks for sharing knowledge in relation to cutting edge low carbon pilot projects. Membership of these networks was also presented as 'evidence' of Frankfurt's leading role in climate action demonstrating the political importance the city places on being perceived as a leading, international city on green issues. In Rhine-Hünsruck TMNs were also recognised as important to the development of local energy programmes with the area participating in a national networking programme called 100ee regions and a number of international networks and programmes, including the European Commission's 'Intelligent Energy Europe' programme.

In Hamburg there was evidence of civil society actor networks coming together in new ways as a result of private actors decisions on energy investments. This included development at the Moorburg plant, and to a lesser degree at Wedel, creating a strong narrative against Vattenfall and a popular movement to 'keep Vattenfall out of Hamburg' (interview 35-NGO). As Becker, Naumann and Moss (2017) suggest this mobilised a wide range of established civil society actors to

[113] Kern and Bulkeley (2009, pp. 309–10) outline three defining characteristics of TMNs; 'First, member cities are autonomous and free to join or leave. Second, because they appear to be non-hierarchical, horizontal and polycentric, such networks are often characterized as a form of self-governance. Third, decisions taken within the network are directly implemented by its members'.

come together in novel constellations in order to successfully challenge urban energy governance norms in the city. This resulted in a narrative of democratic control - to ‘have it in your hand’ as the referendum motto put it - together with a characterisation of Vattenfall as part of the ‘old, dirty system’, which successfully motivated sufficient residents to vote for remunicipalisation. Despite this the close result of the referendum indicates the polarised nature of the debate and the likelihood that contested views on energy system governance remain.

6.7.2 Industry Associations

While a diverse range of actors were engaged in heat networks at a local level interviewees suggested that industry associations, the Big 4 utilities and stadtwerke were particularly influential in shaping the policy environment. In particular the industry associations VKU, AGFW and BDEW were described as influential, although they represent very different memberships. The VKU is the association for local public utilities and represents approximately 1500 municipal companies working in the fields of energy supply, water supply and sewage, waste management, municipal cleaning and telecommunication (VKU, 2016). The AGFW is the Association for District Heating, Cooling and CHP and has approximately 400 members, including district heating utilities, industrial companies, manufacturers and research institutes. BDEW is the German Association of Energy and Water Industries representing 1,800 companies across natural gas, electricity, district heat, water and wastewater (BDEW, 2015). Clearly all three associations have an interest in promoting heat networks however interviewees characterised BDEW as largely representing the large power companies, particularly in relation to gas generation, whilst AGFW and VKU were seen as the representatives of stadtwerke. Regardless of these differences in membership all three were united in lobbying for extensions to the support for gas-CHP and were perceived as working together effectively in relation to the KWK amendments (interviewees 30-TA, 38-TA, 39-TA, 53-MU).

Relationships between and within industry associations were not however characterised as conflict free with VKU representing both municipalities with progressive decarbonisation plans and those invested in coal generation. This was described as generating some internal tensions in the lobbying position of the organisation (32, 45). Despite this the VKU was regarded as closely linked to the Federal government through both the senior management of the association and established links between municipal, regional and national politicians.

The AGFW represents the interests of approximately 90% of the total connected district heating load in Germany and was framed as the national expert organisation in relation to technical standards for heat networks. Although their membership includes a wide range of heat network organisations they have a strong representation of stadtwerke on their Board (including Mainova in Frankfurt) which they suggest means that the perspective of municipalities is particularly influential in their activities (interview 39-TA). Additionally, although they are involved with a number of projects relating to renewable heat networks a number of interviewees saw the organisation as particularly focussed on CHP based heat networks and therefore lobbying strongly for gas-CHP support measures.

These differences in the membership and priorities of the industry associations demonstrates how very different interests can be mobilised around common issues, in this case extensions to the support for CHP, although in the longer-term they may have very different conceptions of the future of heat networks.

6.7.3 Importance of individuals

In England individuals were important in shaping heat network debates at both a local and national level. In contrast the role of individuals tended not to be framed as significant in shaping heat network policy in Germany. This may be partly due to the more established nature and larger size of the heat network industry in Germany resulting in a wider pool of actors engaging in the policy space and therefore less opportunity for specific individuals (or organisations) to dominate the agenda. Additionally the more decentralised governance structures of Germany, with a less elite-based focus on the Federal level, may result in a wider range of non-government actors perceiving themselves to have greater agency in shaping heat networks and energy policy.

An exception to this was the rural case study of Rhein Hünsruck where a strong role was ascribed to local individuals, including district and village mayors and local skilled individuals. For example village cooperative projects were often led by residents with financial or technical skills. Involvement in such projects was framed as an ‘honour’ and ‘not for money but just for ideals’ with the local authority acting in a facilitation role to bring communities wishing to develop low carbon heat networks together to share skills and knowledge (interviews 43-LA, 44-LA, 45-NGO). Strong community commitment and an ethos of working together was repeatedly highlighted and many residents gave skills for free. For example in the village of Fronhofhen a biomass plant is based on a local farmer’s land and he acts as the ‘first call’ engineer on a voluntary basis (interviews 33-LA, 43-LA, 44-LA).

Whilst the role of individuals tended not to be forefronted outside of the Rhein Hünsruck case study a common theme across interviews referred to the importance of local actor constellations and historic relationships between the municipal authority, energy companies, civil society, community groups and local politicians (interviews 30-TA, 43-LA). The complexity of actors involved in heat network projects often led to local authorities being highlighted as key organisations in coordinating development however there was also acknowledgement that local authorities are not neutral actors and may seek to shape heat network development through linking it to remunicipalisation debates (as already discussed in section 6.4.3).

6.8 Institutionalisation

The more decentralised nature of governance in Germany, together with an institutional history that has maintained a level of energy system competence in local government, has resulted in far greater diffusion of influence in the energy system across multiple levels. While interaction between these levels (national, state, municipality, community) in not conflict free, for example with greater focus on community heat networks at a local level, there are established institutional structures to facilitate interaction and coordination across levels. This includes influential industry associations representing heat networks and CHP (AGFW), municipal utilities (VKU) and gas generation (BDEW). Additionally a number of institutions function to link local and national objectives such as the KfW, BMWi city-based programmes and the political influence of state politicians at the Federal level.

There are also fewer institutional norms acting to exclude local governments in the energy system, with an interviewee highlighting that there is a 'very long history of a municipal role in Germany. It's established throughout governance structures and institutions' (interview 37-A). This resulted in municipal utilities being framed as having an ability to meet multiple priorities, operate within competitive markets and deliver public good objectives. This integration of a local government role into energy system norms included the government advocating municipalities taking 'a holistic approach that considers energy strategy as integral to a development strategy for the city as a whole' (BMWi, 2011, p. 30). Another interviewee supported the link between broader decentralisation and a municipal energy role, suggesting that

> 'Germany is a very decentralised country and politicians have their bases set up in a decentralised way. So we find it fairly easy to organise support. If there's an issue that's really very important for us we can ask our members to address their members of Parliament and that usually works quite well because that's the advantage of being locally based as our companies are. It makes it easy to connect to politicians and then they obviously then put pressure upwards to the government' (interview 30-TA).

At a practical level, institutional structures also exist which enable municipalities to develop local 'climate protection laws' which can include supportive measures for heat networks such as banning electric heat and the ability to require connection to a network.

Notwithstanding these institutional structures that support a municipal role in energy, the case studies indicated that heat networks operate in Germany under complex ownership structures and that these structures may shift between (various degrees of) state and market ownership at different points in time. Both the Frankfurt and Hamburg cases demonstrated shifts in local government involvement in heat networks over the last 30 years and suggested that the current trend towards municipal ownership of heat networks was politicised and closely linked to local ambitions to contribute to the Energiewende.

Additionally the Hamburg and Rhein Hünsruck cases demonstrated the complexity of public, private and civil society interactions, suggesting that energy initiatives at the municipal level can 'transcend simplistic notions of public or private ownership' (Becker, Naumann and Moss, 2016). In both cases social movements and civil society were important. The involvement of these groups in energy discourses and decision-making tended not to be formally institutionalised, although there was evidence of their involvement becoming more structured. For example in Hamburg the local authority indicated that it is establishing a board, referred to as a 'Political Chair', to inform and influence the remunicipalised grid companies with an expectation that civil society organisations would be represented (interview 35-NGO). Additionally the strong role of civil society in the Energiewende, initially arising from opposition to nuclear power then later focussed on decentralized energy and local involvement in the energy system, appears to have supported the involvement of civil society in remunicipalisation campaigns. As Fuchs & Hinderer (2016) identify there is a long history of 'regions, cities and villages experimenting with socio-technical innovations' and developing 'governance structures under high uncertainty' based on local actor constellations and socio-political contexts. These combination of factors have resulted in a diverse actor networks being involved in energy policy, investment and operation, with local areas often having some familiarity in navigating energy related conflict.

More broadly the involvement of a wide range of actors is supported by energy system norms in Germany. The German approach to energy transition is generally described as inclusive of community, individual and municipal actors (Fuchs and Hinderer, 2016; Kuzemko *et al.*, 2017) and German policymakers have historically placed strong focus on the sustainability benefits of a decentralised energy system (BMWi, 2010). Additionally the principle of diverse ownership models is well established through both the widespread presence of stadtwerke and a high proportion of renewable generation ownership by individual citizens.

As discussed low carbon city networks were revealed to be important in all three cases for sharing best practice and creating momentum. There was also a norm of collaboration by local energy system actors which was realised differently in the cases. In Frankfurt the involvement of a consortium of municipalities was an important element in the buy-back of Thüga in 2009 and in Rhein Hünsruck community groups, several villages, the local authority and the municipal energy company were presented as collaborating to undertake local energy planning.

The presence of financial institutions that support local investment in energy infrastructure were cited as important by two of the case studies and several national actors. This is supported by research by Hall et al. (2016) and Barton et al. (2015) which both indicated that access to finance from co-operative, state-owned, and local banks is important in the development of municipal and community energy projects.

Additionally there was much less reference to financial pressure on German local authorities than in the England cases with some areas, including Hamburg, being described as being in a ‘comfortable financial situation…and that gives space to experiment with energy system innovations’ (interview 32-A). It is likely that the presence of decentralised institutional structures that support municipal involvement in energy, together with a local ability to experiment in transition arenas is supporting German municipalities to engage closely with local energy transitions and see their role as going beyond setting an enabling environment for decarbonisation.

The significance of local context and history in influencing the creation or maintenance of discourses was evident in Germany where the long history of energy based conflict in Hamburg resulted in a wide range of civil society organisations being mobilised to engage in heat network ownership debates and a willingness of the municipality to consider novel approaches to energy system change (albeit in the context of some local actors seeking to maintain the status quo).

When historical institutionalist theories try to explain change, they most often point to external shocks or critical junctures that determine a change of policy path, leading yet again to stability (Streeck and Thelen, 2005; Schmidt, 2008). Notwithstanding the importance of historical factors the findings of this research highlight that historical institutional accounts of the development of heat networks in England and Germany are not sufficient. The two countries have very different histories (in terms of heat network growth, institutional links between local and national scales and the strength of devolution and austerity discourses) but similar discourses were evident in relation to an ensuring role for local government, increased interest in direct ownership and the need to deliver multiple objectives in both countries, albeit with debate limited in England due to dominance of market liberal ideas at national level.

The research also suggests that, although asymmetrical national-local governance relations limit the scope for local experimentation to shape wider institutional structures, local historical, cultural and political dynamics remain central in shaping trajectories of change. The interplay between local dynamics and the conditioning of local priorities was evident in the fact that although debate of the relative benefits of different ownership structures was current in all locations, these debates achieved more traction and were more able to translate into material change in some locations. Specifically, in Bristol and Hamburg, a combination of a history of politicisation of energy issues, a relatively benign environment in terms of local authority finances and staff numbers, and a window of opportunity to reconsider ownership issues (in Bristol the development of new networks without much historical precedent for particular ownership structures; in Hamburg the end of grid concession contracts), had led to the development of heat network delivery models centred on the local authority.

6.9 Conclusion

This chapter has illustrated how a range of organisations interested in heat networks (and beyond) have converged on a storyline regarding the need enhancing support for gas-CHP networks. In general there was support for existing heat network policy with existing support schemes seen as sufficient.

A norm of varied actor groups being involved in the energy system, the long history of municipal utilities and the presence of various institutions that support the integration of local interest in national energy policy appear to have supporting a strong role for municipalities in heat networks. In particular as considerable local energy system skills have been developed in many cities.

This chapter has also demonstrated the importance of historical context and political culture in shaping the environment for heat networks locally. In Hamburg heat network developments were dominated by the remunicipalisation campaign and framed as an 'ideological debate' focussed on wanting to get rid of Vattenfall. The campaign was high profile with the Chamber of Commerce, energy companies and some of the city government on one side and civil society and others in the government on the other. Specific windows of opportunity relating to developments at Moorburg, Wedel and the grid concessions were highlighted as significant in mobilising a wide range of actors in (re)shaping the energy system in Hamburg.

In Frankfurt there was much less evidence of contestation. There was considerable focus on transitioning the existing networks to renewable sources of heat with a clear mandate from the city government. Mainova did however suggest that balancing multiple priorities whilst continuing to be economic was challenging. The city framed themselves as a transition manager with public ownership of the heat networks as a route to accelerate change, although this did also include the backgrounding of the still significant role of coal in the city. In Rhein Hünsruck there was a strong focus on delivering low carbon networks with municipal and community approaches described as integrated and complementary. The local authority was framed as providing a supporting role and community based individuals were revealed to play an important role. Despite very different histories and ownership structures there was consensus of a resurgence nationally in the role of municipal energy in supporting the delivery of the Energiewende. The role of local government was not seen to be under any particular challenges, compared to the high profile of devolution processes and the financial pressures on local authorities in England.

Chapter 7: Integrating the findings and identifying ideational power

7.1 Introduction

The purpose of this chapter is to consider the six cases, across two countries, presented in chapters 5 and 6 and review how they inform explanations of ideational and institutional change from a city-scale perspective. It brings together the analysis of discourse, actors and ideas to aim to uncover the mechanisms by which discourses shape and are shaped by actor strategies and institutional structures.

In terms of the discursive institutional literature the following sections explore how a DI approach can facilitate a more detailed understanding of institutional change and maintenance across scales. Specifically, while there were many overlapping or mirroring discourses at the national and local scale in both countries (such as the role of heat networks in decarbonisation and the importance of local authorities playing a role in deployment) there was also a disjunct between programmatic and philosophical discourses underpinning national and local approaches, particularly in England. While there was debate of the multiple priorities heat networks can deliver at both national and local levels, there was more critical engagement in what this means for governance and delivery at the local scale. Additionally, English local authorities were seen to be linking discourses from within and outside of energy to reframe philosophical ideas relating to their role in energy system change. In Germany local actors were less tightly constrained by norms and problem definitions, supported by greater historical embedding of the importance of multiple state and market actors in energy systems. Despite this greater openness to ideas of the ‘ensuring state’ the extent of local authority engagement in energy was being further politicised through debate of remunicipalisation and a refocusing on the role of municipalities in driving rapid decarbonisation.

The previous two chapters applied Hajer’s (1995a) structured process for discourse analysis, incorporating the identification of problem definitions, emerging and established discourses, discourse coalitions and institutionalisation. This chapter expands on how discourses constructed, contested and maintained a range of philosophical, programmatic, policy ideas and operationalised the various types of ideational power (power through, over and in ideas) outlined by Schmidt (2008) and Carstensen and Schmidt (2016).

As outlined by Schmidt (2008; 2010), discursive institutional approaches organise ideas at three levels - policy, programmatic and philosophical ideas. Policy ideas shape the options and solutions discussed in relation to an issue, programmatic ideas form the underlying principles of policy including problem definition, policy norms and methods, and philosophical ideas embody the world views, values and underlying assumptions in the policy process. Philosophical ideas are the most deep-seated ideas and tend to occur as background, underlying assumptions which are rarely discussed and contested, except in times of crisis. Philosophical ideas do, however, underpin programmes, which in turn underpin policies (Lorenzoni and Benson, 2014), with ideas at these levels more ‘foregrounded’ and openly discussed (Gillard, 2016). The following section therefore explores the key discourses and ideas evident in the cases and relates them to the dynamics of ideational type or level. As the levels of philosophical, programmatic and policy ideas are inter-related and constructed the analysis is structured by key discourse with ideational types analyses within this. The following section then relates this analysis to realisations of ideational power and institutional change.

7.2 Key discourses and ideational framing

7.2.1 Limits to an all-electric future

As discussed in chapters 5 and 6 there was a common storyline across countries, cases and actor types of the limitations of all-electric approaches to heat decarbonisation, and by extension the importance of heat networks. This storyline tended to be presented based on the cognitive idea that complete heat decarbonisation via electrification would be very technically and economically difficult, and therefore policy should be developed to support heat network deployment. However a variety of programmatic and philosophical ideas were evident to underpin this storyline and ultimately resulted in different approaches to policy.

At a programmatic level in Germany the ‘problem’ of heat decarbonisation was widely (particularly by national actors) framed as the need to integrate heat and power in order to achieve sufficient overall system flexibility to completely decarbonise. This is often referred to as ‘sector coupling’ in German debates and situates heat networks as a fairly central part of overall decarbonisation. This can be seen as both 1) a pragmatic recognition that heat, power and transport systems are likely to become increasingly integrated as decarbonisation progresses, and 2) a means to maintain gas-CHP in the medium-term whilst Germany focusses on the highly politicised issue of phasing out coal power.

In contrast national policy actors in England tended to present a story whereby heat networks were only now being supported as analysis was increasingly indicating that other options were not viable to the extent previous assumed. This relative ‘reluctance’ to support the technology can be linked to philosophical ideational themes in UK energy policy in terms of a focus on centralised, marketised models. This framing promotes a focus on trying to ensure technologies conform to norms of competition and techno-economic rationalities (programmatic ideas) and was identified as a constraining factor by several interviewees (such as 54-C, 55-G, 57-LA, 60-C). This diverged with more local conceptions of heat networks as a multi-dimensional issue which emphasised the variety of local issues that heat networks could contribute to, such as fuel poverty, system flexibility, local revenue and regeneration. In part this resulted in both differing conceptions of the ‘problem’ heat networks were trying to solve (i.e. decarbonisation vs decarbonisation plus social objectives) and differing conceptions of the most appropriate action to support deployment (de-risking commercial investment vs a strong role for the local authority and a long-term perspective on network development).

7.2.2 Multiple priorities

As discussed, at the national level in England there was a somewhat uncritical approach to multiple priorities and 'co-benefits'. Although key policy documents and interviewees made reference to the potential for heat networks to deliver multiple benefits this did not tend to be a central issue in the policy options put forward.

While there was some discussion of the multiple benefits heat networks can deliver in Germany the three city case studies in England tended to problematize the achievement of multiple priorities to a greater degree than either their German counterparts or national actors in the UK. This local debate of the difficulties in balancing social, environmental and economic priorities reflects that all three cases were actively examining local governance structures for heat networks and considering the benefits and risks of various models. In Bristol there was little experience of developing heat networks so there was a lack of a local governance 'template' for local actors to adopt which, in some ways, gave greater scope to consider a full range of options. In this context heat networks were positioned as contributing to climate change and fuel poverty priorities, with public ownership framed as better able to contribute to these objectives. In Sheffield and Birmingham the debate of multiple objectives and governance structures was taking place in the context of existing partnership-based heat network governance frameworks which involved a range of public and private actors. However these existing governance structures were referred to as under review due to changing local government priorities, increasing knowledge regarding heat network operation and broader questions regarding the extent to which multiple objectives can be delivered via existing governance arrangements.

In Germany, whilst the potential to contribute to multiple objectives was recognised, all three cases emphasised carbon reduction objectives over other priorities. This partly reflects the lower profile of fuel poverty concerns in Germany and the more secure financial position of many local authorities. However this may also indicate the greater degree to which some local authorities are engaged in contributing to decarbonisation in Germany.

The connection of a topic to multiple storylines and agendas can be a successful technique to make a new storyline more acceptable to a range of actors groups, partly through interpretive flexibility aiding coalition building and partly through fitting arguments to cognitive and institutional norms (Hajer, 1995). At a high-level linking heat networks to the need to address fuel poverty, decarbonise heat and integrate electricity, heat and transport acted to connect this well-established technology to positive cognitive frames and was unproblematic for a wide range of actors to adopt. This particularly appealed in England due to the ability of heat networks to integrate a range of generation technologies, thereby resonating with the 'technology neutrality' norm of UK energy policymaking. However the difficulties in balancing complex, potentially conflicting, priorities was not widely debated at the national level but a much more current (cognitive and normative) debate at the local level. The interplay of these issues with shifts in philosophical ideas regarding the role of the state are discussed later in this chapter in section 7.2.5.

7.2.3 Unlocking finance

In both countries a very significant proportion of the policy debate at the national level was focussed on issues of financing networks, although the focus of these debates, as well as the underlying ideational themes differed.

In Germany the focus of national policy debates was on the need to ensure that gas-CHP networks remained viable. Here narratives emphasised the countries leadership role in climate action and the need to ensure that coal was phased out rapidly, with gas acting as a 'bridge' to decarbonisation. Whilst some issues, such as the coal phase-out are highly politicised the topic of extending subsidy support for gas-CHP (including many heat networks) was framed as a pragmatic step, particularly given that costs are small when compared to existing costs of renewable electricity subsidies. Additionally, at a practical level, networks had already been developed in many of the key cities so the focus was on ensuring continued viability and expansion.

Exiting coal in Germany is highly politicised, largely due to the significant role still played by coal mining in some regional economies, the reliance of some industries on cheap coal power and the importance of the coal unions both culturally and politically. The politicised nature of exiting coal, together with particularly challenging economics for gas-CHP, therefore provided an opportunity for heat networks to be positioned as part of the 'solution' to the problem of coal. The paradox of heat networks being both closely linked to decarbonisation debates in Germany whilst still incorporating a significant level of coal generation was highlighted by some consultants and NGOs in Germany but Government actors framed gas-CHP as a bridge to a decarbonised system. This illustrates how storylines can position issues with CHP positioned as a 'victim' of electricity decarbonisation at the same time as being important to long-term system flexibility. This appeared to be successful in mobilising multiple actors, including industry, trade bodies, stadtwerke and national government, around the storyline of the need to support gas-CHP and led to change in national policy in the form of the CHP Act amendments. In Hamburg and Frankfurt, whilst there was a commitment to developing renewable heat networks both cities were also actively developing gas-CHP networks to replace coal networks and did not see the use of gas as in conflict with their climate goals in the short-term.

In England the emphasis at the national level was on attracting third party finance to build new schemes. This was leading to a focus on ways to reduce large-scale investor risk, for example through the HNIP which aims to provide capital contributions and loans to heat network projects in order to increase the internal rate of return for equity investors (BEIS, 2016d). Whilst funding was also being made available to support local authority feasibilities the overarching message was that this was to develop projects towards commercial investability.

Discussion of financial barriers and an energy sector norm of the need to 'attract mobile international finance' were enthusiastically adopted by industry participants to focus debate on the need to make heat networks projects investable. Energy sector norms relating to financing are highlighted by Bolton

(2011) and Hawkey and Webb (2012, p.4) who suggest that the emphasis of successive UK governments on privatised energy markets has established an energy infrastructure investment culture based on controlling risk in order to attract global finance with reliable rates of return. The centrality of programmatic ideas which framed heat networks as a techno-economic problem and a technology which needed to be shaped to fit within existing energy system norms reflects the embedded nature of normative ideas regarding the benefits of a centralised, competitive and economically regulated energy system. These themes are returned to below in section 7.2.5 and 7.3.

7.2.4 Regulation and consumer costs

As discussed, in England the presence of deeply embedded norms regarding competition, financing and regulation acted to shape the policy environment for heat networks around the need for them to be shaped to be 'more like' other part of the energy system, notably other supply arrangements. However, the locally specific nature of heat networks means that variations in generating mix, consumer profile and network costs can potentially result in widely different consumer prices which can be difficult to either communicate to consumers or effectively regulate. This is particularly the case as assessments of the heat network prices cannot simply compare network prices to the average unit price of gas as heat delivered by a heat network also includes costs related to heat source maintenance and replacement (the equivalent to gas boiler servicing and replacement).

A number of studies have indicated that in the UK heat network costs, on average, tend to be comparable with gas heating (and generally cheaper than direct electric heating) (Which?, 2015; Competition and Markets Authority, 2018), and heat network consumers are as satisfied with their heating systems as non-heat network consumers (BEIS, 2017c). Despite this there has been growing attention paid to instances of poorly performing heat networks which has led to some organisations to call for more structured regulation (ADE, 2015; Which?, 2015; Citizens Advice, 2016). The CMA's review concluded that the sector should be regulated by a public-sector body which has statutory powers to set regulation, monitor compliance, and enforce regulatory standards (Competition and Markets Authority, 2018).

To date the Government has not issued details of how it envisages regulation operating, however the framing by both government and the CMA has been that a regulator will introduce consumer protection for all heat network customers in line with those received by gas and electricity customers in relation to price, quality of service, transparency and minimum technical standards. Given the comments above outlining the difficulty in comparing heat network prices this illustrates the extent to which normative assessments of how the energy system needs to operate is shaping the heat network policy environment. This can also be seen in the exclusion of alternative discourses relating to other ways to protect consumers and regulate networks. For example in Denmark networks are operated by municipalities or cooperatives on a not-for-profit basis with prices benchmarked publically annually and the Danish Energy Regulatory Authority overseeing the sector (Danish Energy Agency, 2017). Similarly in Germany there was an acceptance within regulatory debates that the structure, customer base and pricing of networks is likely to be very different in different locations and that the most appropriate way to deal with this was through the Federal Cartel Office’s (Bundeskartellamt) ongoing random checks and sector enquiries.

7.2.5 Enabling to ensuring state

As discussed in section 7.2.2 ad 7.2.3, in England there was a significant disconnect between discourses at the national and local scale in relation to both the framing of the policy issues that need to be addressed in order to deploy heat networks, and the wider role of heat networks in the energy system and beyond.

At their root these differing policy and programmatic approaches were informed by a divergence in ideas relating to the role of the local state, particularly in relation to energy system change. This is referred to here as difference between ‘enabling’ and ‘ensuring’ state worldviews, and is perhaps the most central theme of the ideational analysis carried out in this research. It was evident, in different forms, in both countries albeit more strongly in the English cases and is explored in the rest of this section.

As detailed in chapter 2, there are significant difference between local governance structures in England and Germany, including a long established norm in Germany of multiple forms of energy ownership, including municipal ownership (Cox, 2010). However a number of authors have also charted how market liberal principles have been embedded into the operation of the local state across much of Europe (Hood, 1995; Griffiths and Kippin, 2017). This involved a 'reorientation of urban governance away from the local provision of welfare and services to a more outward-orientated stance designed to foster and encourage local growth and economic development' (Hall and Hubbard, 1996, p. 153). These changes led Bulkeley and Kern (2006) to suggest that local government reforms in the UK and Germany over the past 25 years have, to an extent, 'eroded some of the historical differences' with both countries converging on a more partnership based 'enabling' model of governance and engaging less in ensuring, direct delivery modes of governing (termed Governing by provision in their typology), particularly in relation to urban climate governance.

This claim was, however, contested by a range of local governance, NGOs and consultant interviewees in both countries who suggested that this 'enabling' role for local government was being reconsidered to some extent. In England, all three case studies referred to an increased appetite to consider investing in large infrastructure projects and highlighted the benefits of more local authority involvement in terms of long-term planning and multiple objectives. At the national level there was an accepted narrative in both countries that local authorities play an important coordination and brokerage role in relation to heat networks. However in England, at the national level, debate regarding the local authority role tended to focus on the benefits of early stage involvement in terms of feasibility, identifying anchor loads and de-risking involvement for commercial partners and did not enter into much critical debate regarding the implications of local authorities taking a more central ownership and operation role.

Table 12 outlines the modes of governing proposed by Bulkeley and Kern (2006) together with examples of local government use of each mode. The table also includes examples of the multiple modes adopted across the case studies examined in this research.

Table 12: Modes of local governing

Mode of governing	**Examples from Bulkeley and Kern, (2006)**	**Examples from this research**
Self-governing - the capacity of local government to govern its own activities	• Energy efficiency schemes within municipal buildings (such as schools) • Use of CHP within municipal buildings • Purchasing green energy	• Connection of municipal buildings to heat network, particularly as anchor load (all cases)
Governing by authority - the shaping of practice through the delivery of particular forms of service and resource	• Supplementary planning guidance on energy efficiency, renewables and CHP • Guaranteed connection to CHP or renewables	• Local option of requiring connection to heat networks (but rarely used) (Hamburg, Frankfurt) • Local planning guidance to support connection to heat networks (all cases)
Governing by provision - the use of traditional forms of authority such as regulation and direction	• Energy efficiency measures in council housing • Energy Service Provider	• Connection of social housing to heat networks in conjunction with other efficiency improvements in order to reduce bills for residents (Bristol, Birmingham, Sheffield) • Establishment of municipal supply company (Hamburg, Frankfurt, Bristol).
Governing through enabling - Governing through advice,	• Campaigns for energy efficiency • Provision of advice, grants and loans for	• Partnership based heat network delivery models (Sheffield, Birmingham, Rhein Hünsruck).

partnerships and delegation.	energy efficiency or renewables	• Coordination and facilitation of heat network development with public and private partners (all cases)

At the local level in England there was much more local exploration of the various roles local authorities could take in terms of ownership, control and risk and the implications of that across a range of financial, social and environmental outcomes. Birmingham, Sheffield and Bristol, whilst having very different experiences and delivery models for heat networks, were all examining different delivery models for the future and considering a stronger local authority role. This represents a break with the local government approach in the past as initially there was an emphasis in the Birmingham case on the need to partner with a commercial operator in order to manage risk. Similarly in Sheffield the original sale of the network was closely linked to financial and risk-based concerns.

In terms of the national approach to the role of local authority policy efforts and discourses were aligned with programmatic ideas which framed the local (and national) state as playing an enabling role in the energy system and privileged techno-economic rationalities. These programmatic ideas were themselves embedded in a neoliberal philosophy based on markets and competition and a 'hollowed out' state which increasingly delegates its tasks and thus becomes less important (Stoker, 1998; Rhodes, 2007; Schönberger, 2013). This was expressed by national policy actors through an emphasis on marketised approaches, concerns regarding the capability of local authorities to take a more central role and repeated reference to the ability of local authorities to 'enable' investment.

However many local actors presented a clear narrative of how they felt this 'enabling' framing of local government was out of step of wider changes they were identifying in both the energy system and the role of local government. In terms of energy themes there was widespread reference to a perceived failure of competitive energy markets to deliver fair costs, the need to accelerate the speed of decarbonisation and the need to integrate of social and economic concerns into decarbonisation. Additionally the various properties of heat networks which make them difficult to fit into existing (competition-based) energy system norms were highlighted.

Significantly there was also evidence of discourses and ideas from outside of energy influencing the framing of energy issues and efforts to restructure policy and practice with local actors commonly linking debate of heat networks to issues of austerity and devolution. In particular the need to identify sources of revenue was referred to in all three English cases and there were numerous references to devolution (and the relaxing of borrowing rules) ‘unleashing’ local authorities to be more commercial. Importantly this tended to be framed as increased scope, within local authorities, to develop commercial undertakings which can then support wider public services and priorities. This was particularly evident in Bristol’s municipal energy company presenting themselves as ‘a force for social good’ (Bristol Energy, 2017) and in several interviewees specifically using the term ‘ensuring state’ in an explicit rejection of alternative framings (e.g. APSE, 2013).

Whilst it could be assumed that individuals working for local authorities are more likely to hold worldviews which situate the (local) state as a key deliverer of social goods it is important to note that the ensuring state narrative was evident from a number of other (i.e. non-local authority) interviewees (such as interviews 49-NGO, 52-C, 54-C, 56-NGO, 60-C). Additionally, while some individuals may have long-held values which site the local state as central to the delivery of public services, interviewees were specifically reporting a shift in how they thought about a local authority role in relation to energy systems and there were some examples of this being operationalised in terms of Bristol Energy, the approach of APSE Energy and the number of heat networks owned and an increasing number of heat networks operated by local authorities (such as Islington, Camden, Aberdeen).

In Germany there was also some reference to a more ensuring state but this was not framed as in opposition to national framings in the same way. A more complex role for local government is already established in national and local discourses and institutions, with acceptance that they may play multiple roles concurrently. In Frankfurt and Rhein Hünsruck this incorporated coordination, planning and delivery and was based on partnerships which spanned the state-market-civil society spectrum. In Hamburg the role of the local authority was more politicised reflecting the contested nature of energy system change in the city. This involved an increasing local authority role being disputed by some actors, however the referendum had institutionalised a more central role for municipal ownership going forward.

However, despite a well-established openness to local authorities playing a range of roles in the energy system, both case studies and national interviewees also highlighted that conceptions of this role were changing as debate of the benefits of energy system privatisation became more common across a range of actors. This was most politicised in Hamburg where a diverse range of actors had been mobilised in a remunicipalisation campaign which linked private ownership with continued use of coal generation and a lack of local control. Similarly an increase in municipal buy-backs of energy networks and infrastructure in recent years, as discussed in chapter 2, was cited by many actors as part of a wider movement which was rejecting neoliberal approaches to rapid decarbonisation and locating the state (at a range of scales), as well as community organisations, as key to the Energiewende.

In Frankfurt and Rhein Hünsruck, although there was less debate of how local energy governance approaches might be changing, a strong role was already established for local government in driving change in the energy system albeit in different forms in the two locations. In Frankfurt the city took a pragmatic approach to increasing its ownership of Mainova in 2009 indicating that it was both a sound investment and a means to increase control over energy objectives. The current structure of heat network provision in the city was not described as controversial with broad acceptance that the city plays a role in planning, facilitating and providing energy services. Although it should be noted that Mainova highlighted more difficulty in aligning commercial and non-commercial priorities. In Rhein Hünsruck the small, rural nature of networks and the desire to develop 100% renewable systems meant that there was limited involvement from commercial actors with development led by community groups and the municipality. The benefits of local ownership were widely recognised and had been embedded by the development of a significant number of renewable electricity projects over the last 20 years.

7.2.5.1 Remunicipalisation and non-energy themes

In terms of the broader debate of the ‘ensuring state’ narrative there was also a recurrent storyline in both England and Germany relating to the (re)municipalisation of energy. In England although there is currently very little municipal ownership of the energy system there has historically been a higher incident of municipal ownership and operation of heat networks[114] and the recent development of a number of municipal suppliers or electricity and gas. This was closely linked to the ‘changing local government role’ discourse discussed in chapter 5 and related to a need to access new sources of revenue and be more entrepreneurial, as well as increasing reference to the failure of the privatised energy system to deliver social and environmental objectives.

Both Birmingham and Sheffield have, to date, pursued commercial partnership approaches to delivering heat networks while Bristol is pursuing a municipally owned and controlled model. Despite these differences all cases referred to an increased interest in municipal ownership and referred to a wider resurgence of local authority interest in the energy system. However there was much more emphasis on municipal models in Bristol reflecting the linking of heat networks to the establishment of Bristol Energy which had raised the profile of ‘social good’ objectives in the energy system (Bristol Energy, 2015). The normative framing of increased local authority involvement in energy systems delivering better social outcomes was openly framed by some interviewees, both in Bristol and beyond, as informed by philosophical ideas relating to the need for greater local state involvement to deliver rapid and equitable decarbonisation. As one interviewee put it:

[114] Such as in Nottingham and Sheffield.

> 'there is genuinely a populist feeling of we should do something different, we should use the resources we've got in the city to do things better. We've always had a very individualistic approach to things…we want the local authority in our way as little as possible in Britain, that has changed to some extent and the local authorities have to some extent been trying to get that 'we will be your champions' mantle. Big government's not working, central governments not listening to us, we'll do it locally' (interview 17-LA).

Importantly there was considerable reference across cases and interviews to how non-energy drivers, such as devolution and constrained local government finances, were interacting with local governments approach to heat networks (and energy projects more widely). This was highlighted by all cases, particularly Bristol, and indicates how broader structural changes to local governance can influence specific policy areas such as energy. Austerity was often invoked as a rationale for local authorities engaging in local infrastructure projects such as heat networks where low cost local authority finance can be mobilised to deliver long-term (but low rates of) returns. This financial narrative was invariably linked to the wider localism and devolution agenda in that the 'flip-side' of constrained public finances was the message from central government that local authorities could determine their priorities and solve their own problems more independently than before.

In this way the linking of heat networks to both wider climate change and devolution agenda can be seen as a site of both cognitive dissonance and constructive alignment. Firstly, despite the narrative of devolution, local authorities were critical of the extent to which real power was being devolved, echoing the critiques of many political analysts (Deas, Hincks and Headlam, 2013; Lowndes and Gardner, 2016; Tomaney, 2016; Ayres, Flinders and Sandford, 2018). This dissonance between the narrative of devolution and the experiences of local authorities in terms of the lack of new powers and freedoms meant that senior managers in local authorities and non-energy teams such as finance and legal were more open to actual opportunities to act more entrepreneurially, particularly when there was the potential for long-term revenues. Equally while the message from central government was that local authorities should focuss on an *enabling* role in heat networks, even this monir refocussing on local authorities as energy system actors provide a space for some local authority officers to present the narratives of energy system change and devolution as aligned, with closer involvement in heat network delivery as the logical conclusion of this alignment.

Despite being consistently referred to by local actors the (re)municipalisation storyline was not influential in national policy debates which instead focussed on techno-economic appraisals of heat networks and the development of locally negotiated governance structures. However there may be some emergent institutionalisation of a more central role for local government with local authorities starting to collaborate more on energy projects and recent government support focussed on local authorities.

In Germany, while the remunicipalisation storyline was unsurprisingly strongest in Hamburg, there was awareness across interviewees of a resurgence of interest in municipal utilities and the remunicipalisation of significant grid infrastructure across the country. This was linked to the opportunity to buy back grid concessions, a recognition of the need to accelerate the energy transition, and some disillusionment with the ability of private models to deliver multiple energy system objectives.

Additional the need to engage a wide range of local stakeholders in heat networks (regardless of ownership structures) was a feature of debates in both countries. In particular a wide range of public and private delivery models were in place in both countries, with often blurred boundaries between the two. This included complex public-private partnerships and local authorities developing arms-length subsidiaries which may also include commercial shareholding. This highlights how simple conceptions of state or market do not reflect the complexity of actor relations and governance realities in relation to energy transitions, particularly in locally contingent infrastructures such as heat networks.

7.3 Exercising Ideational Power

In order to examine the ability of the ideas discussed in section 7.2 to become influential to a wider range of actors this section explores processes of ideational power. Ideational power can be defined as the capacity of individual or collective actors to influence other actors' normative and cognitive beliefs through the use of ideational elements (Carstensen, 2011). In an effort to provide a framework to analyse how power is exercised through ideational processes Carstensen and Schmidt (2016) developed a framework of three different types of ideational power: power through, over and in ideas. *Power through ideas* can be understood as the ideational capacity of actors to persuade other actors to accept and adopt their views; *power over ideas* relates to the coercive imposition of ideas and the power to resist the inclusion of alternatives; and *power in ideas* takes place through constraining the ideas that can be considered and the establishment of ideational hegemony. The following section relates the key ideational processes identified in the research to these three forms of ideational power in order to explore the route from discursive and ideational framing to institutuionalisation (or not) of particular ideas, norms and policies.

7.3.1 Power through ideas

As discussed *power through ideas* (the most common approach to ideational power among discursive institutionalists) is based on the ability of actors to persuade others to accept and adopt certain views. Persuasiveness depends on the cognitive and normative arguments adopted (Carstensen *et al.*, 2016; Gillard, 2016).

One of the key discourses promoted by central government and industry actors related to the idea that heat networks are a techno-economic 'problem' which requires a focus on de-risking investment. This cognitive idea, is superficially appealing as creating a financable business case for heat networks is a key challenge in most cases. However, it was limited in its persuasiveness for many local actors as it did not align with local framings of the problems heat networks can help to address. Instead local authority interviewees focussed far more on challenges relating to simultanteously delivering multiple priorities via heat networks, how to progressively decarbonise heat generation, and ensuring connection risk was minimised through engaging a wide range of local stakeholders.

The techno-economic framing can be seen as based on normative arguments about the nature of the 'right' way to deliver energy policy (see section 7.2.3 on marketised approaches to energy policy). However this normative stance tended to be out of step with what Widmaier, Blyth and Seabrooke (2007, p. 755) refer to as the 'intuitions of the moment' in terms of locally constructed cognitive and normative expectations about how policy and the economy should/could work. While Widmaier et al.'s (2007) analysis referred to the relationship between mass public expectations and specific policy arenas, a parallel was evident in this research at the local scale with numerous energy and non-energy themes coming together (i.e. the key themes outlined in section 7.2) to create an environment that allowed some local actors to construct a 'new' role of local authorities in energy system change. The fact that this more ensuring role aligned with various energy and non-energy themes limited the persuasiveness of the entrenched national framing of an 'enabling' role.

Although the framing of heat networks and the role of local authorities was more nuanced in Germany a similar shift in cognitive and normative expectations about the energy system at the local level can be seen in terms of the salience of remunicipalisation narratives. Indeed there was much more evidence in Germany of wider public mobilisation on the issue of local authorities and energy system change, with public campaigns in support of municipal ownership of energy infrastrcuture taking place within Hamburg, Berlin and other locations (Terhorst, 2014; Becker, Naumann and Moss, 2016).

As highlighted by Carstensen and Schmidt (2016, p. 325) process of *power through ideas* tend to emphasise actors' 'ability to 'stand outside' and critically engage with the ideas they hold and promote'. In this way 'actors not only have 'background ideational abilities' that enable them to think beyond the (ideational) structures that constrain them...They also have 'foreground discursive abilities' that enable them to communicate and deliberate about taking action' (Schmidt, 2008, p. 6). However despite extensive evidence of local authorities in England critically engaging with the philosphical and programmatic underpinning of their approach to energy systems, a lack of formalised engagement of local actors in national energy policy debates was limiting opportunities for these ideas to be incorporated into national debates. In Germany where more structured institutions exist to engage local interests in energy policy (such as a stronger tier of regional politicians and trade associations which represent the interests of stadtwerke) ideas relating to a more central role for local authorities were more established in national debates.

In England, whilst there was limited evidence of local actors persuading national policy actors of the importance of a more 'ensuring' state and municipal ownership, the strength of these debate between groups of local actors appeared to help them to resist the ideational power of established norms about energy system operation (see *power in ideas*, 7.3.3). At the local level persuasively utilising cognitive and normative ideas about how and why local authorities should take a more central role in heat networks was important in local actor networks as evidenced by the fact that all six cases were actively (re)considering the balance of risk, reward and control of different ownership models and seeking to take a more central role in local energy planning (somewhat regardless of final heat network ownership structures). These debates about the 'correct' role for local authorities to play in energy system change were also a topic of current debate in several local governance networks such as APSE, the Core Cities, UK100 and in international actor networks such as Energy Cities and ELENA.

7.3.2 Power over ideas

The concept of *power over ideas* relates to the capacity of an actor, or group of actors, to control and dominate the meaning of ideas. Carstensen and Schmidt (2016) suggest that may involve directly imposing ideas, indirectly pressurising opponents into conformity or by excluding alternative ideas.

In this study direct *power over ideas* was less evident that the other forms of ideational power. Partly this results from the complexity of actor networks involved in heat networks and their locally contingent nature meaning that it is more difficult for ideas to be consistently imposed across a policy arena. For example, while in England there was a clear national focus on unlocking finance for heat networks and fitting them into existing energy system norms there was also recognition that a diversity of ownership, operation and financing models were already in existence and the most appropriate local arrangements will ultimately be informed by local conditions and networks.

Additionally the fact that heat network development was being linked to multiple policy areas (particularly locally, see 7.2.2 and 7.2.5) meant that a wide range of ideas and approaches to delivery were being discussed locally, creating a difficult environment for any nationally imposed idea to have hegemony.

As Carstensen and Schmidt (2016) outline this form of ideational power tends to more more evident in circumstances when policy is being shaped by a closed group of people, such as an epistemic community, that can mobilise enough legitimacy around their policy ideas to avoid considering alternative approaches. This can also be the case in area of high technical or scientific complexity where 'challenger' ideas can be more easily excluded. In Germany one example of the exclusion of alternative ideas was the focus on supporting gas-CHP as the main focus for heat network policy. While this was resisted by some minority (NGO) voices, contestation to this programmatic idea was largely excluded due to the strength of the coalition of (climate activist, industry, municipality) interests which were aligned in lobbying for more support for CHP.

7.3.3 Power in ideas

The final form of ideation power – *power in ideas* – relates to the authority of some ideas to structure wider thought on a topic, or to constrain the ideas that can be legitimately considered. This tends to relate ideational power to structural and institutional forms of power in terms of how norms and institutional set-up shapes the ability of actors to promote their ideas. In terms of constraining what can be meaningfully be considered, *power in ideas* overlaps to some degree with *power over ideas,* however this form of power tends to be exercised more implicitly in terms of norms and standard ways of operating rather than the explicit exclusion of a view point.

In England *power in ideas* was evident in terms of the strength of the energy systems norms relating to the importance of industry knowledge in forming energy policy and the need to de-risk investment for commercial finance. While these norms did not explicitly exclude local authorities from the policy process they served to legitimise existing institutional structures which limited local authority engagement in the policy process. For example, there were limited agreed tools to incorporate the valuing of social outcomes into the appraisal of heat networks, and engagement between government and other actors focussed on industry associations (mainly ADE). While local authorities are engaging with government on heat network much more than they did in the past this tends to be through the HNDU and focus on the practicalities of carrying out feasibility studies rather on wider debates of the future of the policy agenda. Indeed several local authority interviewees highlighted the difficulty in engaging with national heat network policy debates due to limited resources and the need to focus on the dynamics of their acutal projects (interviews 62-LA, 64-LA, 66-LA).

A number of sub-national and NGO interviewees in England suggested that the options open to supporting heat networks were framed by the need for them to fit within the principles of the current energy system (interviews 3-NGO, 5-NGO, 14-C, 15-NGO, 16-LA). In the UK the central tenets of the energy system include supplier choice, competitive energy markets and the dominance of privatised energy companies (Henning and Mårdsjö, 2010). The assumption that these main structural features of the UK energy system are set and not part of the debate 'blackboxes'[115] both the different characteristics of heat networks in comparison to other decarbonisation options and the fact that the wider energy system is undergoing significant disruption which could involve broader challenges to norms relating to supplier switching and the nature of energy

[115] Blackboxing is a discursive mechanism which makes an issue appear as fixed, essential and beyond discussion (Hajer, 1995a).

companies. Specifically Hall and Foxon (2014) suggest the UK energy system developed based on competitive markets for generation and supply and the regulation of distribution and that this creates difficulties for heat networks as generation, distribution and supply are often integrated and long-term contracts are necessary in order to secure the high levels of upfront capital costs. Heat networks also tend to be monopoly suppliers once established as the cost to consumers of switching heat source, either to gas or to an alternative low carbon system, tends to be prohibitive.

Despite the strong drivers to fit heat networks within existing energy system norms there was a growing ideational challenge at the local level to the idea that local authorities should only facilitate energy system change. Instead a refocussing on an 'ensuring' local state was linked to much wider debates relating to public finances, devolution and the need to deliver multiple energy system priorities. Cowell *et al.* (2017, p. 5) suggest that as political devolution can 'represent a significant re-territorialisation of government and political processes' it might be expected that it would have a significant effect on energy system governance norms. The analysis here provides some evidence of an effect on local governance norms albeit with limited evidence of this being integrated into national norms.

In Germany there was evidence of more flexible institutional norms with acceptance, and formal institutionalisation, of a wide range of organisations engaging in the energy system through a mix of state, non-state and quasi-state actors. This led to an environment for local projects which was not particularly constrained by norms regarding the 'right' way for local energy systems to develop. This was partly driven by a less ideological commitment to marketised models of energy supply in Germany's coordinated market economy, which accepts the inclusion of a variety of voices in policy debates, and privileges compromise and the formation of coalitions (Kemfert & Horne, 2013). Additionally the presence of a significant number of municipal utilities throughout the history of the German energy system also meant there was greater discursive space when grid concessions were due for renewal and a number of cities decided to remunicipalise energy networks (Wollmann, 2004).

German energy policy and wider governance confers significant autonomy on local energy actors and this established local role is supported by central policy support and the existence of a national technical and regulatory framework.

There was also a tendency in Germany towards pragmatic policy making that accepts that sufficient rather than perfect consumer protection arrangements are acceptable. This led to less debate of consumer protection or heat network regulation, despite widespread acknowledgement that there were some limitations in the ex-ante regulation approach of the Bundeskartellamt. Instead norms around the need to rapidly move away from coal use had led to debate being largely dominated by the need to support gas-CHP.

While there was a relative lack of discursive conflict regarding heat network development at the national level, there was considerable local politicisation of energy in the Hamburg and Rhein Hünsruck cases. In Hamburg this was part of a long history of energy related conflicts where various aspects of the energy system were disputed by different environmental, social and economic interests. In Rhein Hünsruck politicisation was less conflictual, in that the municipal and community interests were dominant and portrayed as aligned, but significant social capital had been mobilised around issues of energy system ownership and development. As Moss *et al.* (2014: 2) suggest such local debates can reflect 'intense debates about how each locality stands to benefit or lose out from the Energiewende and how it can intervene to advance its own – and broader, collective – interests'.

In constrast to these examples of local (re)politicisation, depoliticisation is framed as a key route through which *power in ideas* is exercise in terms of constraining legitimate points of view. Significant differences in the local politicisation of energy were evident between the case studies and countries studied. In general, debate of ownership was more politicised at a local level in both England and Germany with limited national debate of these issues. Hamburg and Bristol in particular sited their decisions on heat network ownership in relation to the failure of privatised energy systems. However in Germany there was more engagement of citizens in this politicisation with citizens, community groups and civil society closely involved in discussions regarding the future of local energy infrastructure in both Hamburg and Rhein Hünsruck. Despite this politicisation of heat networks at the local level in England, in particular, the agenda was depoliticised at the national level through the discursive hegemony of ideas of techno-economic rationalities and derisking investment.

7.4 Institutionalisation and incremental ideational change

Analysis of the role of discourses in socio-technical transitions often consider specifically the interaction between discourses and policy change (such as Kern, 2009) and Schmidt and Radaelli (2004, p. 188) argue that new discourses can provide ‘actors with new ways of conceiving of a policy’ leading to the reconceptualization of actor interests and policy change. This study builds on this perspective but, in line with much of the wider discursive institutionalist literature, considers institutional change from a broader perspective than policy change, incorporating other formal and informal institutions. Discourses can therefore enable or constrain the role of actors or promote new actors engaging in a policy area which leads to different outcomes in relation to the priorities, norms and business practices pursued by actors involved in heat networks, somewhat regardless of policy. For example, increased debate of the role of heat networks in delivering complex local priorities and a reconsideration of the role of municipal ownership in some local authorities was influencing the approach of many of the case study cities and leading them to adjust how they appraised the risks and benefits of different approaches to heat networks, without explicit policy to drive this change.

In Germany the presence of diverse heat network ownership structures and actor networks, together with the long-term existence of public utilities, meant that there were recognised routes for municipalities to have a voice in policy debates. This included both political influence through the Federal political structure of Germany and heat network policy influence through the VKU and AGFW. Additionally the established role for stadtwerke meant that a less dichotomous relationship between state and market delivery models was established with these municipal companies seen, to some extent, to mediate between state and market as they operate with commercial objectives and can include private investment.

Additionally, in Germany there was a wide range of institutional structures, operating across a range of scales, which represented local interests in energy policy. These included technical representation by the AGFW, public ownership representation in the form of VKU, CHP lobbying by the BDEW and more structured links between local politicians and national government. This is not to say that there was no conflict between interests and a number of NGO interviewees highlighted instances of both public and private actors simultaneously promoting the role of heat networks in decarbonisation whilst also seeking to still operate fossil fuelled networks or owning coal generation plant. There was also more national debate regarding local public ownership of the energy system which was largely lacking in England.

In contrast, in England, while an increasing role was recognised for local government in heat (albeit largely portrayed as an enabling role at the national level), there was limited formal mandate. There are few structures through which local government can influence the wider national energy landscape and a large number of interviewees highlighted how, although some local authorities were likely to be very effective in driving heat network development, variation in local resources and skills was likely to lead to uneven and patchy development of networks nationally. Despite these concerns the developing role of the HNDU team and the HNIP were seen as the beginnings of a formalisation of a greater role for local government, although with the focus still on the commercialisation of projects.

As Carstensen (2011, p. 596) emphasises most ‘theories about ideas in politics implicitly conceptualise ideas as relatively stable entities that act as a catalyst for political change in times of crisis’ but ‘overlook incremental yet significant ideational change in times of stability’. This is also true of discursive institutionalist literature which tends to say little about how ideational change can occur incrementally. Schmidt (2002, p. 223) does hint towards more incremental conceptions of ideational change in her framing of ‘evolutionary change' when policy discourses are renewed and there may be 'minority discourses waiting in the wings proposing alternative policy programmes'. However overall she still argues that significant policy change happens through crisis.

In order to make DI more sensitive to incremental ideational change Carstensen (2011) proposes the notion of ideational bricolage. This refers to ideas as being comprised of a web of related elements of meaning whose presence, linkages, and relative importance is prone to (incremental) change over time. These incremental change are easily overlooked, or even deliberately downplayed, but their cumulative effect and influence on policy can be significant (Gillard, 2016).

In the cases examined in this research, while there was strong evidence of a city-scale ideational shift to a more ensuring role for local authorities (in heat networks) in both countries, there was limited evidence of a single 'crisis' driving these changes. Instead, particularly in England, interlinked economic, political and technical decentralisation trends were observed to be coming together to create the discursive space for local authorities to re-evaluate their role in energy systems. This incorporated; economic trends relating to austerity and reductions in local government funding, political trends in relation to devolution and a focus on local economic growth; and technical decentralisation trends in relation to energy systems which are becoming more localised and focussed on the need to decarbonise heat. Whilst some of these trends lent from 'crisis' narratives in relation to austerity and the need to rapidly decarbonise they were woven together to create a more incremental bricolage where storylines from multiple topic areas combined to allow local actors to create a compelling argument for a more interventionist role in energy infrastructure.

However, despite these local ideational shifts, institutional norms and wider governance traditions persisted which were limiting the ability of local governments to enact a more central role in energy systems. Specifically a lack of institutional structures to include local authorities in energy policy debates and a national norm of 'enabling' modes of urban climate governance appeared to be limiting the ability of local authorities to translate the ideational power they were exercising within their organisation and with peers (*power through ideas*) into influence on national policy. This highlights the ability of ‘power in ideas’, exercised through national norms and policy making processes, to constrain other types of ideational power – particularly those that originating from local actors.

In Germany the ideation shift towards a more ensuring local state was less pronounced, largely due to the fact that a more varied role for the local state was already historically and institutionally embedded. However there was a significant shift in the local politicisation of remunicipalisation discourses with (some) local debates moving from a position that both state and market had place in local energy infrastructure to a position that local democratic bodies (municipalities and community groups) should be *the* key agencies in shaping the development of energy infrastructure. This was particularly evident in Hamburg and Rhein Hünsruck and tended to draw on storylines relating to the need to accelerate decarbonisation far more than the English cases, although local discourses in both countries also drew on narratives of a loss of confidence in the private sector to deliver the best outcomes.

7.5 Conclusion

This chapter has outlined the ideational underpinning of the key discourses discussed in chapter 5 and 6. It explored how a range of philosophical, programmatic, policy ideas were constructed, contested and maintained through processes of power through, over and in ideas. In particular it demonstrates how processes of ideational bricolage were being utilised by local actors in England (and to some extent in Germany) to bring together energy and non-energy debates and enable the local contestation of philosophical ideas relating to the role of the local state in energy systems.

Currently much discursive institutional literature presents ideas as influencing policy outcomes only when fully formed (Carstensen and Schmidt, 2016; Gillard, 2016), however, the findings of this research suggest that emerging, chaotic and conflicting ideas can also be powerful. In England ideas relating to an ensuring state and ‘remunicipalisation’ were being used in a variety of contexts (electricity generation, energy supply, power networks, heat networks) to illuminate broader trends regarding the localisation of energy systems and the potential role of local authorities in delivering multiple local benefits. This debate was not substantially shaping national policy but beginning to influencing practice and approaches at a subnational level. However at the same time obdurate existing storylines, such as the need to focus on unlocking finance for heat networks, can act to marginalise other storylines. This highlights the complex interaction between dominant and emerging storylines with ideational bricolage at the local level leading to a reappraisal of the role of local government in energy system change. This was, to a degree, providing a route to resist embedded national norms and establishing a platform for ideas relating to a strong local governance role to be established in debates of decarbonisation and energy system change.

Chapter 8: Conclusions

8.1 Introduction

This final chapter reflects on the previous results, analysis and integration chapters (chapters 5-7) and clarifies the contribution of the work to debates of (urban) energy system change. It sets out how apply a discursive institutional approach can help to conceptualise urban energy governance and proposes that being sensitive to the scalar dynamics of ideational power provides for a more detailed understanding of how power in, over and through ideas relate and the notion of ideational bricolage. It also sets out how this approach can enrichen MLP approaches to socio-technical change.

Firstly sections 8.2-8.4 consider each of the research questions posed in this research. Section 8.5 discusses these findings in relation to contributing to discursive institutionalist, urban governance and MLP literatures. The final sections (8.6 and 8.7) discuss the policy implication so of the research and propose areas for further study. Overall the research reveals the complex interdependencies between national and sub-national government in constructing and delivering energy system transformation. It suggests that processes of governance rescaling are interacting with the dominance of different ideas about the role of the (local) state in energy transitions. It also illustrates the struggles about meaning inherent in processes of change but suggests that these struggles play out differently at different scales.

While the last 20-30 years have seen an increase in the development of marketised forms of local governance, such as contracting and public-private partnerships, this research suggests there is a growing appetite in local governments in both countries to adopt more direct forms of governance in order to secure wider public good benefits of energy infrastructure. City actors are playing a role in shaping the ideational context and institutional structures relating to heat networks, however this role is also constrained by powerful institutional norms relating to the functioning of the energy system. A range of different processes and capacities are also evident between, and somewhat within, countries. In particular local authorities in England have no mandate or structure for strategic local energy planning and it remains to be seen if a more central role in relation to heat networks (and other energy infrastructure) will fully establish. Whilst many of the comparisons drawn in this chapter refer to differences and similarities between the English and German cases there was also significant variation between cases in each country. Complex, location specific, discursive dynamics - together with local political, social, economic and infrastructure histories - were critical in shaping each location's approach to heat network development.

8.2 How are heat networks developing in England and Germany?

8.2.1 Which public and private actors are engaging in this scale of energy provision and why?

As discussed in chapter 2, heat networks have only relatively recently been given an increased profile in England and Germany as part of energy transition discourses. Despite this local authorities have historically played a central role in heat network delivery in both countries, often linking the development of networks to economic growth, regeneration and social objectives, although some have been linking heat networks to carbon reduction priorities for several decades. To date local authorities, particularly in England, have tended to deliver heat networks through partnerships with commercial actors and large utilities, but increasingly local authorities appear to be seeking to take a more central role in both countries.

This process has involved the engagement of local government in heat networks becoming more structured. In Germany this tended to include heat networks increasingly being linked to national Energiewende priorities, growing numbers of stadtwerke seeking to own and operate heat networks, and the embedding of a range of heat network and local governance institutions at a national level. In England this is through support for heat networks increasingly being focussed on local authorities as central coordination organisations, and (some) local governments developing revitalised competencies in the energy sector through the development of low carbon projects and municipal utilities.

The actor networks involved in heat networks are more established in Germany with several industry associations representing heat network interests. These associations tend to be well embedded in local, national and European policy processes and there was a perception across interviewees that a range of voices were incorporated into the policy process. In England actor networks were characterised as less established and more chaotic due to the embryonic status of the industry. However, local authorities were increasingly becoming the centre point for activity, although they had limited involvement in national policy processes.

8.2.2 What storylines and discourses are being adopted by actors in the development of heat networks?

A number of influential problem definition storylines relating to heat networks were emerging in England and Germany, with a degree on commonality between the two countries. Key storylines included: heat policy neglect, the multiple priorities heat networks can contribute to, challenges of financing, regulation and - most significantly - the (changing) role of local government in relation to energy system change.

In terms of initial problem framing the development of a strong discourse relating to the neglect of heat decarbonisation provided an opportunity in both countries to consider heat networks in a different context. This includes the focus being put on their ability to integrate multiple forms of low carbon generation and meet multiple objectives.

The ability of heat networks to potentially integrate a range of objectives, both within and beyond the energy sector[116], was recognised in both Germany and England and consistently discussed in all case study locations. Despite this all three city case studies in England tended to problematize the achievement of multiple priorities to a greater degree than at the national level, where the difficulties in balancing complex, potentially conflicting, priorities was not widely debated. In Germany, whilst the potential to contribute to multiple objectives

[116] As discussed in earlier chapters, objectives include carbon reduction, energy system flexibility, lower costs for fuel poor residents, regeneration and local revenues.

was recognised, all three cases emphasised carbon reduction objectives over other priorities. This partly reflects the lower profile of fuel poverty concerns in Germany and the more secure financial position of many local authorities. However this may also indicate the greater degree to which some local authorities are engaged in contributing to decarbonisation in Germany.

The challenge of financing heat networks was a theme in all locations and but with some significant differences in the debate between the two country contexts. In particular all three of the German cases referring to the importance of the local and national public banking sectors which provides low cost capital for projects that meet carbon reduction objectives. In England there was emphasis at the national level on attracting third party finance which was leading to a focus on ways to reduce large-scale investor risk, for example through the HNIP, which aims to provide capital contributions to heat network projects in order to increase the internal rate of return for equity investors (BEIS, 2016d). At the local level there was more focus on analysing the potential for local authority investment in networks, framed in terms of the lower cost of capital this might enable, the ability to deliver social objectives and as a response to financial pressures on local authorities. These differences between the national and local levels illustrates how energy system norms relating to the need to control risk to attract mobile international finance may be embedded at a national level but subject to more contestation locally.

In terms of regulation and consumer protection, although there was some debate regarding the limitations of the ex-post regulation of heat network prices in Germany there was a general consensus that the current framework for regulation and consumer protection was sufficient. There was considerably more debate of regulation and consumer protection in Hamburg than the other German cases, reflecting the politicised nature of energy debates in the city.

In England there was far greater debate of future regulatory options for heat networks, partly due to their current unregulated nature. Consumer associations emphasised the need for regulatory measures particularly in relation to pricing and dispute resolution (Which?, 2015; Citizens Advice, 2016). The monopoly nature of heat networks was particularly cited reflecting the extent to which institutional norms regarding the importance of competition in delivering customer outcomes are embedded across actor groups, including those interested in consumer protection.

8.2.3 What discourses are dominant in the different contexts?

8.2.3.1 The role of Local Government

Discourses relating to the most appropriate role for local authorities to play in heat networks, and energy system change more broadly, were a central theme in local debates. This included debate of the multiple modes of governing which local government can/should mobilise in energy system change, particularly in relation to the balance between enabling and ensuring approaches, and a locally situated narrative in both countries relating to (re)municipalisation and energy.

Overall the importance of local government playing a role in heat network development was an established narrative in both England and Germany. There was acceptance at the national level in both countries and across all cases that local authorities play an important coordination and brokerage role in relation to heat networks. Despite this in England there was more local exploration of exactly what sort of local government role might enable the best local outcomes to be achieved across a range of financial, social and environmental outcomes. In Germany a more complex role for local government was established, with acceptance that they may play multiple roles concurrently. However locally debates regarding the role of re-municipalisation in accelerating the energy transition were being renewed.

Incorporating discussion of the relative risks and benefits of (re)municipalisation into consideration of the modes of governing available to local authorities in energy transitions was a theme in both England and Germany. In England although there is currently very little municipal ownership of the energy system there has historically been a higher incident of municipal ownership and operation of heat networks[117] and the recent development of a number of municipal suppliers or electricity and gas. The role of re-municipalisation was closely linked to a range of energy and non-energy themes such as a need for local authorities to access new sources of revenue and be more entrepreneurial, a rethinking of the role of local government in light of the devolution agenda, and increasing reference to the failure of the privatised energy system to deliver social and environmental objectives.

In England despite being consistently referred to by local actors the (re)municipalisation storyline was not influential in national policy debates which instead focussed on techno-economic appraisals of heat networks and the development of locally negotiated governance structures. In Germany, while the remunicipalisation storyline was unsurprisingly strongest in the politicised energy policy environment of Hamburg, there was awareness across interviewees of a resurgence of interest in municipal utilities and the remunicipalisation of significant grid infrastructure across the country. This was linked to the opportunity to buy back grid concessions, a recognition of the need to accelerate the energy transition, and some disillusionment with the ability of private models to deliver multiple energy system objectives. The exploration of these ‘modes of governing’ debates were therefore supporting cities to create their own discursive space on urban energy governance, informed by ideational framings not necessarily shared by national actors.

Notwithstanding the similarities and differences between key discourses, all the cases studied also revealed the importance of locally contingent networks and historic contexts in shaping network development and governance structures. For example in Sheffield a strong local narrative relating sustainable energy to economic competitiveness and the ‘green economy’ was important in creating political momentum for expanding heat networks, as was the cities long history of operating heat networks. The local authority’s familiarity in coordinating action between public and private sector agencies was significant, but a more recent focus on opportunities for the local authority to develop revenue raising

[117] Such as in Nottingham and Sheffield.

projects appeared to be influencing its approach to future network development. In contrast, in Bristol, a strong narrative of being a leading city on climate change, together with political support for energy projects and a history of local public sector partners working together allowed heat networks to be positioned as an important part of the cities long-term climate objectives. The wider context of the city establishing a municipal electricity and gas supply company, as well as the flexibility provided by a lack of historical delivery models, also prompted the city to reject commercial ownership or financing of the networks. The significance of local context and history in influencing the creation or maintenance of discourses was also evident in Germany where the long history of energy based conflict in Hamburg resulted in a wide range of civil society organisations being mobilised to engage in heat network ownership debates and a willingness of the municipality to consider novel approaches to energy system change (albeit in the context of some local actors seeking to maintain the status quo). Similarly the depoliticised development of heat networks in Frankfurt, with the city buying back a majority share of the utility Mainova with limited public debate, had persisted to the present day with the growth and decarbonisation of heat networks largely framed by a range of local actors as a technocratic process.

8.3 How are heat networks engaging with, and potentially influencing, wider national and international transition processes?

8.3.1 How do wider governance structures influence the development of heat networks in different contexts?

In Germany the presence of diverse heat network ownership structures and actor networks, together with the long-term existence of public utilities, meant that there were recognised routes for municipalities to have a voice in policy debates. This included both political influence through the Federal political structure of Germany and heat network policy influence through the VKU and AGFW. Additionally the established role for stadtwerke meant that a less dichotomous relationship between state and market delivery models was established with these municipal companies seen to mediate between state and market to some extent.

In contrast, in England, while an increasing role was recognised for local government in heat networks there was limited formal mandate. There are few structures through which local government can influence the wider national energy landscape and a large number of interviewees highlighted how variation in local resources and skills was likely to lead to uneven and patchy development of networks nationally. Despite these concerns the developing role of the HNDU team and the HNIP were seen as the beginnings of a formalisation of a greater role for local government, albeit with the focus still on the commercialisation of projects.

8.3.2 How do city-scale heat network projects interact with national policy and institutions?

In England interactions between local heat network projects and national policy and institutions tended to be informal with a lack of capacity to engage with policy debates reported by sub-national actors. None of the case study locations reported close engagement with national policy formation although all were engaged with the HNDU in some form.

Importantly there was considerable reference across cases and interviews to how non-energy drivers, such as devolution and constrained local government finances, were interacting with local government's approach to heat networks (and energy more widely). This was highlighted by all cases, particularly Bristol, and indicates how broader structural changes to local governance can influence specific policy areas such as energy.

In contrast, in Germany there was a wider range of institutional structures, operating across a range of scales, which represented local interests in energy policy. These included a diverse group of trade associations as well as more structured links between local politicians and national government. There was also more national debate regarding local public ownership of the energy system which was largely lacking in England. This involved the topic being relatively high profile nationally and Hamburg and Rhein Hünsruck seeking to engage the wider public in debates regarding ownership.

8.4 What role do city-scale actors play in shaping the ideational and institutional framework for heat networks in England and Germany?

Discourses promoting a more entrepreneurial role for local government and questioning the ability of marketised models to deliver complex, locally contingent outcomes were beginning to have a transformative effect on some actor's conception of the role of the local state in the energy system in England. This was evident to some degree in all three English case studies and was a wider theme in interviews with NGOs and other local governance organisations, although not high profile in central government interviews. This storyline of a changing local energy governance role is still forming so these conclusions are tentative. However further establishment was being limited by the wider institutional norms of the energy system in UK relating to the dominance of a market liberal approach. This storyline was more embedded in Germany, partly due to the historic institutionalisation of more complex decentralised governance but there was equally a resurgence in discourses of municipal ownership.

Chapter 2 detailed the difference between local governance structures in England and Germany, including a long established norm in Germany of multiple forms of energy ownership, including municipal ownership (Cox, 2010). However a number of authors have also charted how market liberal principles have been embedded into the operation of the local state across much of Europe (Hood, 1995; Griffiths and Kippin, 2017). This involved a 'reorientation of urban governance away from the local provision of welfare and services to a more outward-orientated stance designed to foster and encourage local growth and economic development' (Hall and Hubbard, 1996, p. 153). These changes led Bulkeley and Kern (2006) to suggest that local government reforms in the UK and Germany over the past 25 years have, to an extent, 'eroded some of the historical differences' with both countries converging on a more partnership based 'enabling' model of governance and engaging less in ensuring, direct delivery modes of governing.

This claim was contested by a range of local governance, NGOs and consultant interviewees in both countries who suggested that this ‘enabling’ role for local government was being reconsidered. In England, all three case studies referred to an increased appetite to consider investing in large infrastructure projects and highlighted the benefits of more local authority involvement in terms of long-term planning and multiple objectives. Despite this, norms regarding local government playing a market commissioning role and the need to attract mobile finance appear to be strongly embedded, particularly at the national level, although the development of the HNDU and HNIP represent some refocusing on the role of local government.

In Germany local energy governance was more embedded in the energy regime with all three case studies indicating that there was an expectation that local governments could play a range of enabling, ensuring and coordinating roles in relation to the energy transition. The case studies and national interviewees consistently highlighted that the benefits of energy system privatisation were being question and that this was interacting with debates regarding the role of local governments in rapid energy system change. This was most politicised in Hamburg where a diverse range of actors had been mobilised in a remunicipalisation campaign which linked private ownership with continued use of coal generation and a lack of local control. However, even in this context there was a wide acceptance of the co-existence of a range of public and private actors in the local energy regime.

8.5 Contribution

8.5.1 The limits of historical institutionalism

Analysis of the discursive framing of heat networks in the cases and country contexts indicates that an increased emphasis on local public ownership is related to both material (perceived) interests (such as the need to identify revenue sources, or the challenge of delivering multiple objectives), and but also related to changing, ideational factors. Examples include ideas about the role of (local) government in sustainability transitions, the risks of partnership with the commercial sector and the importance of delivering complex, multiple objectives. Several of these themes challenge, to a greater or lesser degree, the dominance of market liberal ideas in the energy system.

The findings of this research highlight the significance of historical contexts in shaping the ability of ideas relating to the role of local authorities in energy system change to establish and influence wider institutions. This was the case at both national and local scales; for example in Germany the long history of municipal ownership and operation in the energy system meant that there are significant energy sector skills within many local authorities, a familiarity with operating revenue generating operations, and established mechanisms for engaging with policymakers. At a local scale Hamburg, in particular, demonstrated the importance of local historical context with an extensive history of energy system politicisation creating an environment where a range of actors were engaged in energy issues, and ideas about energy system operation and ownership were regularly debated. In Bristol the city's long history of action on climate change, the existence of several Green party councillors and other political figures with environmental priorities and the development of a municipal supply company based on trust/social good priorities resulted in an environment that was open to local authority-led approach, sceptical of public-private partnerships and seeking to develop a long-term strategic approach to energy.

In areas where energy issues were less politicised historical factors were still important, for example in Frankfurt the long history of the stadtwerke operating heat networks effectively meant that the continued ownership and operation was largely seen as a technocratic project. Similarly Birmingham and Sheffield both have long histories of partnership approaches to heat network development which were influential in shaping current heat network discussions.

Notwithstanding the importance of historical factors the findings of this research highlight that historical institutional accounts of the development of heat networks in England and Germany are not sufficient. The two countries have very different histories (in terms of heat network growth, institutional links between local and national scales and the strength of devolution and austerity discourses) but similar discourses were evident in relation to an ensuring role for local government, increased interest in direct ownership and the need to deliver multiple objectives in both countries, albeit with debate limited in England due to dominance of market liberal ideas at the national level.

8.5.2 Ideational power and bricolage

The findings demonstrate how local ideational change can be limited by embedded discourses and institutions in relation to both energy system operation and the role of local authorities. However, an ideation shift was identified in relation to the importance of an ensuring role for municipalities and the role of (re)municiplisation. The findings also indicate that gradual processes of ideational change are important with the discursive space for these themes to come to the fore created by complex interlinkages between multiple decentralisation trends.

This incremental framing highlights the importance of ‘background’ discursive processes and frames processes of change as gradual and dynamic. In England in particular interlinked economic, political, technical decentralisation trends were, together, creating the discursive space for local authorities to re-evaluate their role in relation to energy. This incorporates; economic trends relating to austerity and reductions in local government funding, political trends in relation to devolution and a focus on local economic growth; and technical decentralisation trends in relation to energy systems which are becoming more localised and more focussed on the need to decarbonise heat. These multifaceted drivers indicate that processes of endogenous and exogenous change are interrelated in complex ways. This also suggests that DI approaches may tend to over-focus on the strategic use of ideas by actors, as it is unclear if the interplay between technical, political and financial decentralisation factors was adopted strategically by actors. For example, political devolution and green growth discourses were propagated by central government (and other governance actors) and were influential in shaping local government conceptions of energy system change as an economic opportunity but it seems unlikely that the interplay between devolution, green growth and remunicipalisation was anticipated by government and policymakers.

Schmidt (2008b, p. 306) emphasises that philosophical ideas are rarely contested, except in times of crisis and occur as back-ground, underlying assumptions. On the other hand both policy ideas and programmatic ideas tend to be regularly discussed and debated and can be described as ‘foregrounded’. This research suggests that the contestation of philosophical ideas can be constituted through not a single large-scale crisis but the amalgamation of several challenges to existing ideas. A loss of confidence in the private sector to deliver the best outcomes, a financially constrained public sector, growing familiarity with sustainable energy projects in many local authorities and increasing recognition of the potential for heat networks to support the integration of the heat and power sectors[118] have all led to ideas about the role of local government in the energy system to be challenged. Hence ideas can be influential, potentially at different scales, without necessarily being dominant nationally, or used consistently across local actor networks.

Drawing on Carstensen's (2011a, 2011b, p. 147) notion of ideational bricolage the findings of this research suggests, not just that actors express agency through bringing together different ideas into new forms, but that actors such as local authorities which lack both agency and structural advantage may use ideational bricolage as a route to resisting the power of embedded ideational and institutional norms and challenging nationally constructed *power in ideas* at the local level.

8.5.3 Transition literature and the Multi-Level Perspective

As discussed in chapter 3 there are well established critiques of the extent to which the multi-level persepctive on socio-technical change accounts for regime interactions across scales. The findings of this research suggest that applying a discursive institutional approach is valuable in adding richness to explorations of regime politics, particularly in relation to revealing the complexity and spatial variation involved in processes of change.

[118] As well as the basic properties of heat networks in terms of being local infrastructure that requires local coordination.

As discussed in section 3.2.1 MLP approaches to understanding socio-technical change characterise regimes as generally stable with relatively short periods of change initiated by niche experimentation before a new equilibrium is established. Drivers for change tend to considered to stem from pressures at the landscape level (exogenous changes in selection pressures) or radical innovations (endogenous change) (Geels, 2010). Recognising the need to develop a more detailed understanding of the links between endogenous and exogenous drivers, as well as the dynamics within endogenous change, Geels and Schot (2007) distinguish four transition pathways of substitution, transformation, reconfiguration and re/de-alignment, with each displaying a different combination of actor, technology and institutional dynamics. Firstly the (1) Substitution pathway is based on disruptive niche technologies which are sufficiently developed when landscape pressure occurs. Direct struggles then take place between (sets of) technologies and actors which aim to influence institutions, (2) Transformation refers to gradual change through the reorientation of incumbent actors in the context of landscape pressure, (3) Reconfiguration is based on niche-innovations and regimes combining to trigger a transformation of the system architecture, and (4) De-alignment and re-alignment are where an external shock disrupts the existing regime, allowing the rise of multiple competing niche-innovations, one of which gradually becomes dominant.

Geels *et al.* (2016, p. 896) expand on this characterisation of transition pathways to consider how shifts may occur between pathways, arguing this allows less focus to be put on external landscape pressure and more on shifting actor coalitions, struggles, and institutions. They also align various forms of institutional change, as outlined by Mahoney and Thelen (2010) with each of the pathways. These forms of institutional change can be summarised as (1) layering, in which new rules are layered on top of or alongside existing ones without affecting their core logic; (2) drift, in which implementation incrementally leads to policy changes without any institutional decision to do so; (3) conversion, in which old institutions are redeployed to new purposes, and; (4) displacement, in which new institutions slowly over-take existing ones. Generally ‘layering’ and ‘drift’ are characterised as more incremental changes to existing institutions, while ‘displacement’ and ‘conversion’ represent more significant change.

They suggest a transition may shift between pathways, displaying different forms of institutional change. For example, a transition may ‘start as an incremental transformation pathway, based on limited institutional pressure (‘layering’), but subsequently morph into a more substantial reorientation pathway if increasing institutional pressure incentivises incumbent firms to diversify or switch towards new technologies’ (Geels *et al.*, 2016, p. 901). This perspective enables a more fluid understanding of shifts between pathways over time as well as on the processes of endogenous enactment. However this tends to focus on large-scale shifts between transition pathways and less on the potential for differing pathways to be dominant at different scales at various points. In contrast the findings of this research suggest that pathways (and the types of institutional change taking place) can vary between the local (city) and national scale. For example the national pathway in England can be understood to align more with a transform pathway with the drive to develop new heat decarbonisation strategies allowing incumbent actors to argue for incremental policies which support financial de-risking and regulate heat networks in line with existing energy networks (layering). At the local level the pathway aligns more closely to reconfiguration with a range of changes to ideas within the urban energy regime combining to allow (some) local authorities to transform their local approach (displacement), albeit with little change to the national system architecture. Applying a DI approach to understanding ideational power and bricolage allows for the examination of the processes by which competing discourses and ideas, at different scales, can influence transition pathways.

Additionally, sub-national initiatives are often framed in the transitions literature as experimental ‘niches’ which are both enabled and constrained by wider social and political structures (Geels, 2014; Fuchs and Hinderer, 2016). This constructs locally communities ‘passively as seedbeds, but not as originators of powerful transition-oriented initiatives’ (Fuchs and Hinderer, 2016). However this study suggests that locally driven discourses, although clearly interacting with wider philosophical level storylines, can be influential as originators of new (local) governance frameworks. This was seen in the increase in municipal utilities in both countries, with all case studies constructing storylines which centred local authorities in delivering multiple energy system objectives locally. However, despite established links between these local discourse and material changes to local energy regimes there was limited evidence of influence on national governing regimes. This differing engagement of central and local government in heat networks ownership debates illustrates the potential 'conflicts and tensions between actors and institutions embedded at different scales' in the energy system (Bolton & Foxon, 2013: 2207). Similarly the findings suggest that obduracy is not experienced in the same way across social-techincal systems with some (local) areas more able to experiment and adopt new ways of doing things based on both their historical context and local regime politics.

Scholars such as Geels *et al.* (2016) and Andrews-Speed (2016) have already started to argue for more integration between institutionalist and socio-technical transitions approaches. This research supports this call and provides evidence that applying an institutional approach can provide a deeper understanding of both endogeous drivers for change within the urban energy regime and how transition pathways can differ between national and sub-national scales. As emphasised by Späth and Rohracher (2010, p. 14) 'Cities and regions can be a very important arena of struggles about how to develop socio-technical regimes' however it remains unclear the extent to which they can contribute to reconfiguration at other governance scales'. Further research, tracing the future development of heat networks (and other local energy infrastructure), as they become established could help to fill this research gap.

8.6 Policy implications

The findings of the research suggest a number of issues and recommendations relevant to heat and wider energy system planning.

Firstly, the findings indicate that there is a need to develop better tools to integrate social and environmental benefits into the heat network financial calculus. This relates particularly to the long-term planning of heat networks, where it is currently often difficult to build in passive provision to allow for future network growth. As Cowell *et al.* (2017) indicate the sub-national scale can be a key strategic space for managing tensions between economic and environment priorities so it is important to ensure mechanisms exist to balance local economic and non-economic issues. Heat networks may also provide considerable energy system value in terms of future proofing and keeping options open – such as the ease with which low carbon generation technologies can be retrofitted – these values do not accrue to local actors regardless of whether they are public or private and there is a need to further consider how such value should be accounted for.

Policymaking should also recognise that, somewhat regardless of ideational factors, the drivers behind many local authorities taking a more central role in heat networks relate to a lack of any other coordinating body to plan local energy infrastructure between multiple local organisations. For example multiple public sector organisations (NHS, councils, Universities) are often key actors in network development, networks may cross local authority borders and heat networks may provide considerable energy system services in terms of reducing peak loads and integrating renewables, however current energy system governance does not provide structures to coordinate and manage action at this scale. These processes are more established in Germany where municipalities play a stronger role in energy planning (for example with powers to require connection to heat networks and significant influence over energy requirements in new developments). In England there is a need to reconsider whether a stronger local energy planning role is required, this is particularly the case as power, heat and transport are becoming both more integrated and more decentralised.

The National Infrastructure Commission, in recent analysis of future heat infrastructure options, recognised the role of heat networks in reducing emissions at a low cost and suggested that there may be a role for local authorities in facilitating local coordination of heat decarbonisation technologies. This included highlighting that 'it may be appropriate and beneficial for the public sector – most likely through the local authority – to develop 'heat zoning' policy to incentivise and/or regulate the use of different heating and other energy technologies' (Element Energy and E4tech, 2018, p. 10). Assessment of the role of local actors in energy system planning should include consideration of the role of heat zoning and planning policy in incentivising a locally co-ordinated approach to decarbonisation across vectors.

More broadly there is a need for consideration and debate of the links between different scales in energy transitions, particularly in relation to intrinsically local infrastructure such as heat networks. This could involve the development of more collaborative relations between national institutional structures and sub-national actors and regulatory systems that are less siloed and nationally focussed. In England practically this could include measures to encourage local areas to include energy priorities in Devolution Deals as this would provide one forum for local/national discussion of priorities and barriers. Stronger measures to ensure local public actors are included in policy working groups and engaged in policy design may also be beneficial.

It is also relevant for policymakers to note the complex interactions between energy system change and broader devolution trends. Whilst this research suggests that some local authorities are adopting a stronger ensuring role in local energy system change, given the financial pressures many authorities are experiencing and the lack of any statutory requirement to address energy system planning, it is likely that smaller and less resourced areas will not be in a position to take a central role in local energy system change. Given that heat networks are unlikely to progress without local government involvement this may have implications in terms of the speed and location of heat network roll out.

8.7 Limitations and further research

In identifying the limitations of this research and areas for further study it should be noted that several of the (particularly English) cases were still developing their approach to heat networks and were debating various ownership structures. Although the need to generate revenue was identified by many of the cases as a significant consideration it was unclear the extent to which this factor would shape decision-making. In this regard there is extensive literature on both, the move towards a more enabling, partnership based state (at multiple scales), and urban entrepreneurial governance (Harvey, 1989) where the priorities of urban governance are focussed on local economic growth with locations competing to attract inward investment and skilled labour. In this context further research could usefully explore the extent to which public sector austerity in England is acting as an opportunity to challenge this marketised framing of the city with post-neoliberal and ecological alternatives (Brenner, Peck and Theodore, 2010; Lowndes and Pratchett, 2012; Oosterlynck and González, 2013; McCann, 2017).

Some authors have suggested that the transferral of the impacts of the global financial crisis from the financial sector to the national state and then (partly) on to the local state through austerity represents 'just another phase in the ongoing neoliberal restructuring of cities' (Peck, Theodore and Brenner, 2010; Oosterlynck and González, 2013, p. 1076). However further examination of energy remunicipalisations could provide insight into the relationship between austerity, entrepreneurialism and ecological approaches to governing.

The focus of this research on the interactions between scales in energy transitions also meant that the priority was to collect data from across multiple locations and scales. Unavoidably this meant that some of the nuance of competing local views on urban energy transitions were not captured in each case study. For example community energy groups (apart from in Rhein Hünsruck and Hamburg) were not interviewed in each location. Further exploration of individual cases could expand on the dynamics of competing views of urban energy transitions within cities. Whilst these issues were explored in most detail in the Hamburg case study – as the location where energy was most politicised and the widest range of actors mobilised – further exploration of those who claim to speak on behalf of energy transitions in other cities would be valuable.

While this research considered local political history and the wider politicisation of energy in case study locations a broader piece of research could consider the role of different forms of political leadership in shaping the approach of cities to energy transitions. At a high-level, the cases in England tended to be Labour-led councils (or have a history of Labour leadership) and the German cases tended to have significant Green Party local influence. Further work could probe these themes in detail.

As discussed earlier in this chapter although all the cases studied in this research were what could be described as ‘climate leader’ authorities, it is important to note that ‘municipalities that have pursued a comprehensive, planned approach to climate governance are few and far between and most have encountered significant challenges related to institutional capacity and political economy’ (Bulkeley, Castan Broto and Maassen, 2013, p. 361). Given that a large number of municipalities are not pro-active in energy system change more comparative work on the processes at play in leading cities compared to inactive cities could help to expand understandings of local climate leadership.

More specifically to heat networks, further large scale survey work could assess the outcomes of various different ownership and operation models to draw conclusions regarding the financial, environmental and social outcomes achieved under different structures. This could incorporate analysis of the extent to which those local areas generating revenue from heat networks are able to reinvent this in fuel poverty and other social objectives.

Appendix 1: Non-heat network specific policy support in the UK

Due to their low penetration in the UK heat network policy has always been rather peripheral in energy policy, although there have been periodic spikes in interest in their potential. For example, post-1970's oil shocks, the Government commissioned the Marshall Inquiry which recommended the expansion of CHP heat networks in major UK cities as a route to securing increased efficiency and resilience in the UK energy system (Dodd, 2008). However by this date North Sea gas reserves were being exploited and these plans were not pursued by the incoming Conservative government in 1979, in favour of focussing on North Sea oil and gas, together with nuclear power (Conaty, 2011; UKERC, 2013). There have therefore been limited specific policy measures to promote heat networks in England, although a number of broader policies aiming to promote renewable heat or industrial decarbonisation interact with heat networks. This includes policies such as the Climate Change Levy which incorporates an exemption for heat networks, and the Renewable Heat Incentive (RHI) which provides tariffs for a range of renewable heat technologies that can be utilised in heat networks (Connor *et al.*, 2015). This appendix summarises the financial incentives and support schemes aimed at low-carbon energy technologies in the UK which interact with heat networks.

As the majority of heat networks are based on CHP generation, policy relating to CHP development is particularly relevant to the development of heat networks. From the 1990's a number of Government targets and policies have aimed to increase CHP capacity, recognising the efficiency benefits of the technology. Initially a target was set in 1993 to reach 5GW of CHP capacity by 2010. This target was not achieved and a second target, to reach 10GW of 'Good Quality' CHP (GQCHP[119]) by 2010, was set in 2000. This target was also missed and instead 5.950MWe of GQCHP was in operation in 2010 which fell to 5,571 MWe in 2017 (BEIS, 2017a). Policy measures to support these targets have included potential eligibility for Renewable Obligation Certificates,

[119] 'Good Quality' CHP is a quality standard based on efficiency and environmental performance and is certified by the CHP Quality Assurance Programme operated by government.

Renewable Heat Incentive, Carbon Price Floor relief, Climate Change Levy exemption (in respect of electricity directly supplied), Enhanced Capital Allowances and preferential Business Rates. Further details of these measures are included in appendix 1. However a number of studies have suggested that these measures have been unsuccessful in driving deployment of GQCHP due to the low price of electricity relative to the cost of natural gas and difficulties in small scale electricity producers interacting with centralised energy system structures (as discussed in more detail in section 2.7, see also Toke and Fragaki, 2008; Kelly and Pollitt, 2010).

Between 2002 and 2010 there was some specific support for heat networks in the form of grant funding, with the Community Energy Programme (CEP) and the Low Carbon Infrastructure Fund (LCIF) both providing capital grants. From 2002 to 2007 the CEP provided grant funding of up to 40% of capital costs of heat networks and supported projects in Aberdeen, Birmingham, Woking and Southampton. From 2009 – 2010 the LCIF supported the development of district heating in housing growth areas in England and allocated £21 million to 13 projects (Sustainability West Midlands, 2014).

- Carbon Price Support (CPS) exemptions. Carbon Price Support is a levy on emissions associated with fossil fuel use in power generating plants with a capacity of more than 2 MW. Heat networks with good quality gas CHP are exempt from paying the carbon price floor on the fuel used to generate heat and, from April 2015, for the electricity they use on site. The Association of Decentralised Energy (ADE) estimate that for 2015/16 suppliers will save over £3 per MWh under this policy. However, the CPS exemptions do not include exported electricity generation. Fuel used in the main incumbent heating technology (gas boilers) is also exempt from the CPS.
- Climate Change Levy (CCL): The CCL is a levy on energy (including natural gas and electricity) supplied to commercial, industrial, agricultural and public sector energy consumers. Good quality CHP is exempt from paying the levy on all gas and electricity used internally. The ADE estimates that this policy saves generators almost £2 per MWh for gas and

over £5 per MWh for electricity. As this policy is focussed on business use, it is likely to support building-level gas CHP, rather than suppliers of district heat networks that are connected to domestic users. As with the CPS exemptions, the CCL is that it does not incentivise electricity generation for export (Frontier Economics, 2015; DECC, 2015b).

- Enhanced Capital Allowances: This policy allows 100% of capital investment on Good Quality CHP to be offset against corporation tax or business income tax liability in the tax year in which the investment was made. However it's unlikely to have a significant impact on heat network projects as the long payback of heat networks means that few schemes will earn sufficient profit to have a tax liability within the relevant investment period. Companies with other profitable activities against which to offset their heat network investment may however benefit from the scheme.
- Business Rates: Embedded Good Quality CHP plant and equipment is exempt from business rates.
- Energy Company Obligation: ECO is a government scheme that requires large suppliers to deliver energy efficiency measures to domestic properties in the UK. Connections to heat network schemes will be eligible for ECO financial support in certain circumstances although suppliers are required to 'bank' their energy efficiencies within a two to three year period. Given long investment lead times for district heat, there is a high risk that efficiencies are not realised within this period. As such, suppliers tend to opt for alternatives which deliver energy efficiencies sooner.
- Renewables Heat Incentive (RHI): The RHI is a long-term support scheme for renewable heating schemes. Renewable heating for heat networks is eligible for support under this scheme, which, provides funding through a tariff paid for each kilowatt hour of heat produced from renewable sources. The launch of the RHI in 2008[120] represented a significant shift from grant based schemes to long-term tariff support

[120] The RHI was introduced into UK legislation in the 2008 Energy Act but the commercial scheme came into operation in 2011 and the domestic scheme in 2014.

(Connor *et al.*, 2015) but its primary aim is to support renewable heat technologies rather than heat networks specifically.

- Capacity Market: The Capacity Market is the UK's mechanism for ensuring adequate flexible electricity generating capacity exists to meet demand during times of electricity system stress. Gas-CHP is eligible to participate in the Capacity Market. However the majority of current CHP plant is unlikely to participate in Capacity Market auctions as these sites tend to self-supply electricity rather than export it to the grid due to the low value of export power. The Association of Decentralised Energy (ADE) has also suggested that a number of features of the capacity market design mean that it is not feasible for CHP heat networks to participate.
- Renewables Obligation: The Renewables Obligation was introduced in England and Wales in 2002 to support electricity generation from renewable sources. It closed to new generating capacity on 31 March 2017 however existing networks which receive heat from renewable CHP plant, may be claiming support via the RO where a 0.5 Renewable Obligation Certificate (ROC) uplift for Good Quality CHP.
- Zero Carbon Homes policy: The Zero Carbon Homes policy announced in 2006 set a target for all new homes to be zero carbon by 2016 and made provision to enable this through the planning system, the Code for Sustainable Homes, and Building Regulations. Under the Code for Sustainable Homes heat networks could be employed to help developers meet the zero carbon standard in England. These standards were, however, cancelled in 2015 with the focus now on building regulations to drive down emissions from new buildings.
- Licence Lite: Obtaining a good price for the electricity produced in CHP plants which provide heat to networks can be critical to the viability of networks. In order access higher retail prices for electricity generation some distributed energy generators, including CHP, wish to supply their generation directly to consumers rather than selling it to a third party. Recognising this issue the Government and Ofgem developed License Lite arrangements in 2009 which allow smaller scale electricity generators to gain better access to the electricity supply market and

obtain a higher price for their power. To date only one license lite derogation has been issued in 2017 with interested parties suggesting that the complexity and costs of development such arrangements with third parties have limited interest in the scheme.

- Planning policy. Local authorities are encouraged to consider low carbon and renewable heat networks through the National Planning Policy Framework published last year. The framework encourages local planning authorities to identify opportunities for development can draw their energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.
- EU ETS: Combustion over 20 MW is included in the EU ETS. This means any boiler or CHP plant supplying heat to a heat network over this size requires EU ETS permits. This cost is not faced by domestic gas consumers. As the emissions cap is tightened, there will be an increasing disparity between the costs for gas faced by heat networks and for domestic boilers.

Appendix 2: Interviewees

Name	Organisation	Category	Abbreviation in text	Country
Benjamin Dannemann	Germany Renewable Energy Agency	NGO - Environment	NGO	Germany
Bertram Fleck	Ex-District Administrator, Rhine-Hunsrück	Local authority	LA	Germany
Christian Maaß	HIC Hamburg Institut Consulting GmbH	Consultant	C	Germany
Daniel Ballin	Bundeskartellamt (Federal Cartel Office)	Government	G	Germany
Dr. Günter Hörmann	Vorstand, Verbraucherzentrale Hamburg (Consumer Association, Hamburg)	NGO - Consumers	NGO	Germany
Fabian Schmitz-Grethlein	VKU, Head of Energy Generation (German Association of Local Utilities)	Trade association	TA	Germany
Frank-Michael Uhle	Climate Protection Manager, Kreisverwaltung Rhein-Hunsrück-Kreis	Local authority	LA	Germany
Jens Acker	Federal Ministry of Economic Affairs and Energy (BMWi)	Government	G	Germany
Joel Schrage	Project Manager, Department for Heat Contracting, Hamburg Energie	Municipal utility	MU	Germany
Katharina Seegelke	Bund Hamburg (Association for the Environment and Nature Conservation Germany - Friends of the Earth)	NGO - Environment	NGO	Germany
Kay Pöhler	Vice President, Product Management Infrastructure, KfW bank	Other	O	Germany
Kerstin Walberg	Heat network lead, Hamburg City Administration	Local authority	LA	Germany
Kirsten Hasberg	Distributed Energy Consultant	Consultant	C	Germany

Klaus Jacob	Freie University Berlin	Academic/Research	A	Germany
Lars Holstenkamp	Leuphana University	Academic/Research	A	Germany
Marc Meurer	Simmern Hunsrück public utility (Energieversorgung Region Simmern, VG-Werke Simmern Hunsrück)	Local authority	LA	Germany
Maria Grajcar	AGFW (Energy Efficiency Association for heating, cooling and CHP)	Trade association	TA	Germany
Martin Breitbart	District Heating Sales, Vattenfall Hamburg	DH utility	DHU	Germany
Paul Fay	Energiereferat Stadt Frankfurt am Main (Energy Department)	Local authority	LA	Germany
Simon Weber	Heat Network Unit Manger, BDEW (German Association of Energy and Water Industries)	Trade association	TA	Germany
Simona Rens	German Energy Policy Advisor, Danish Government	Government	G	Germany
Thomas Gebhart	Head of Heat, Mainova Aktiengesellschaft	Municipal utility	MU	Germany
Wendelin Friedel	Abteilungsleiter Konzernentwicklung (Head of Corporate Development, Stadtwerke Frankfurt am Main)	Municipal utility	MU	Germany
Sören Becker	Leibniz Institute for Regional Development and Structural Planning (IRS)	Academic/Research	A	Germany
Alastair Mumford	Senior Project Manager, RegenSW	NGO - Environment	NGO	England
Andrew Filer	Enviroenergy Nottingham	Municipal utility	MU	England
Anna Bright	Sustainability West Midlands	NGO - Environment	NGO	England
Bruce Geldard	Parsons Brinkerhoff	Consultant	C	England
Charlotte Large	Heat Networks Delivery Unit, BEIS	Government	G	England
Fabrice Leveque	Energy and Heat, WWF UK	NGO - Environment	NGO	England

Hanae De Rochefort	Policy Manager, Association for Decentralised Energy (ADE)	Trade association	TA	England
Helen Andrews Tipper	Carbon Trust Public Sector Programme	Consultant	C	England
Ian Manders	Danish Government UK Policy advisor	Government	G	England
Josh Thurmin	Centre for Sustainable Energy	NGO - Environment	NGO	England
Mark Bramah	APSE Energy	Local authority	LA	England
Mark Simpson	Business Development Manager, E.ON Community Energy	DH utility	DHU	England
Martin Crane	Director, Carbon Alternatives (formerly SSE)	Consultant	C	England
Martin Holley	Centre for Sustainable Energy	NGO - Environment	NGO	England
Matthew Aylott	Which?	NGO - Consumers	NGO	England
Michael King	Consultant	Consultant	C	England
Nicky Butterworth	Policy Advisor, Heat Networks Delivery Unit, BEIS	Government	G	England
Paul Barker	Energy Infrastructure Manager, Bristol City Council	Local authority	LA	England
Paul Woods	Concession Director, Cofely	DH utility	DHU	England
Peter Ellis	Deputy Head of Planning - Infrastructure and Environment Division, Department for Communities and Local Government	Government	G	England
Peter North	Senior Manager, Sustainable Energy, Greater London Association	Local authority	LA	England
Richard Rees	Strategic Energy Delivery Officer, Birmingham City Council	Local authority	LA	England
Richard Scott	Head of Community Energy, E.On	DH utility	DHU	England

Robert Almond	Policy and Project Development Manager, Sheffield City Council	Local authority	LA	England
Rufus Ford	Heat Networks Development Manager, SSE	DH utility	DHU	England
Simon Woodward	Chairman, UK District Energy Association	Trade association	TA	England
Tim Rotheray	Director, Association for Decentralised Energy (ADE)	Trade association	TA	England
Tony Norton	Director, Centre for Energy and the Environment, University of Exeter	Academic/Research	A	England
Zoe Guijarro	Policy Manager, Citizens Advice	NGO - Consumers	NGO	England

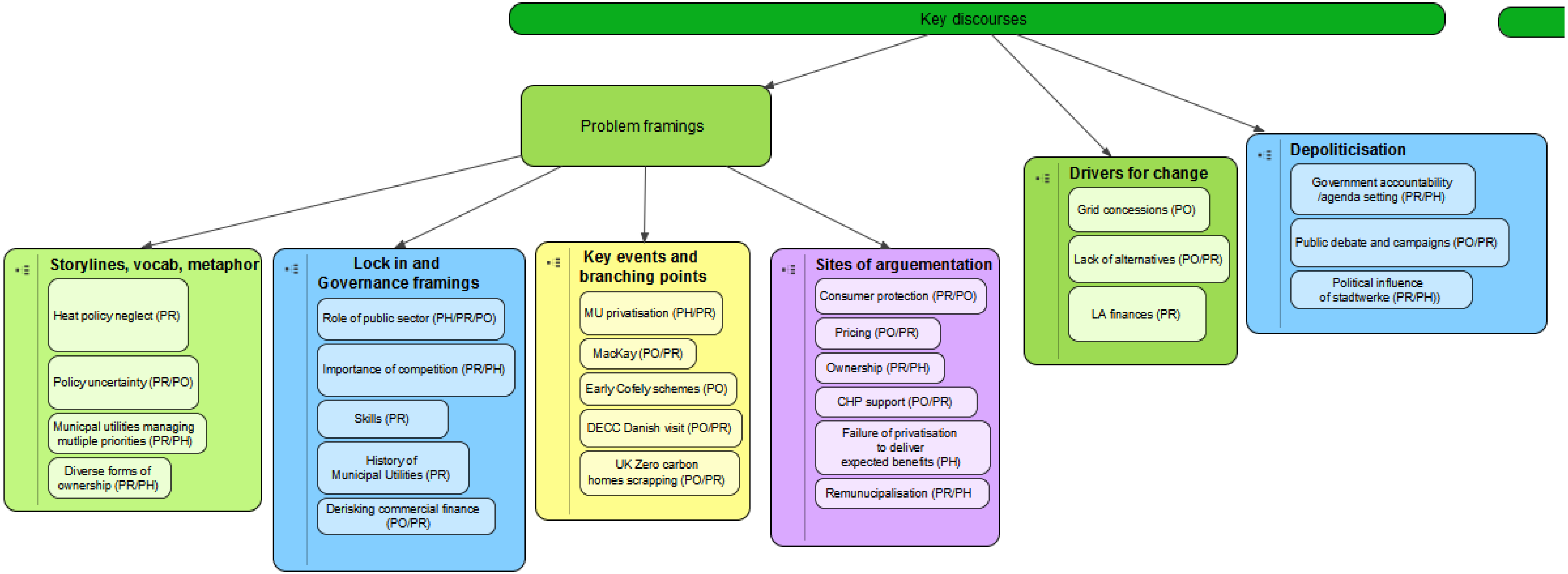
Appendix 3: Interview Guide

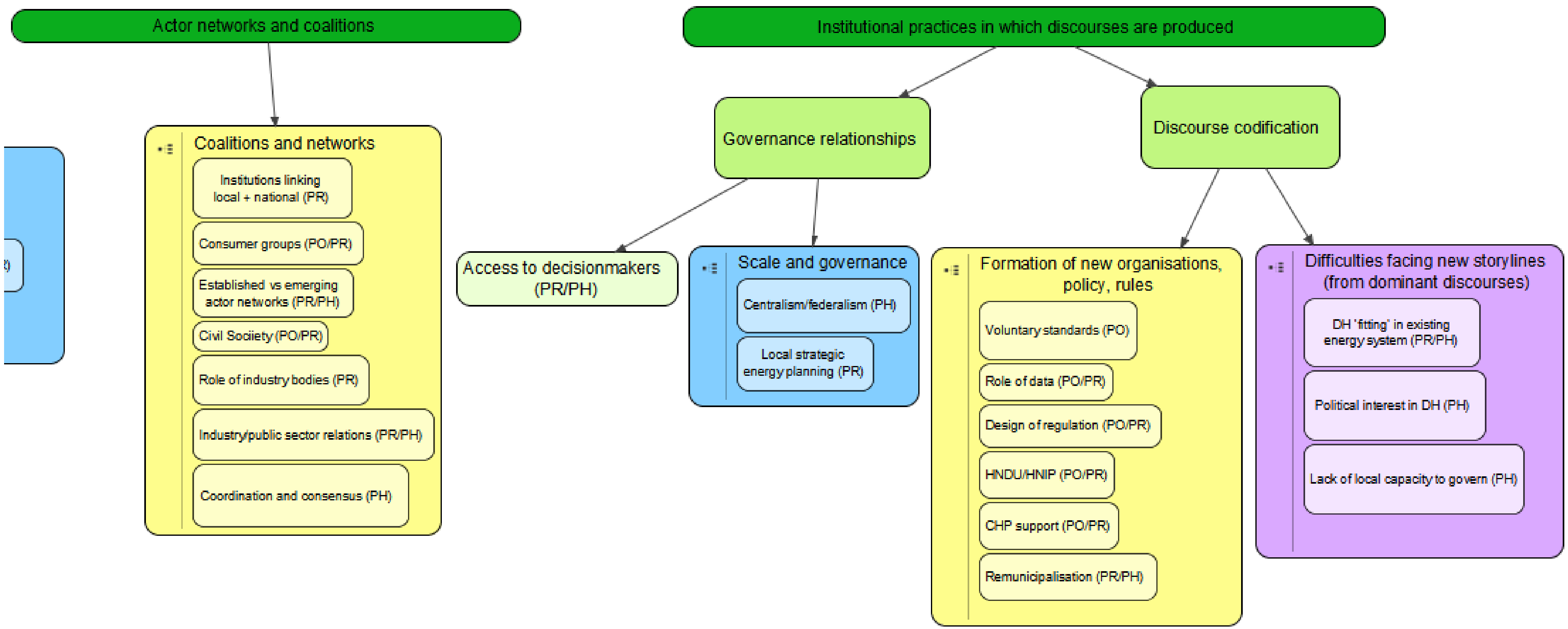
No.	Question	Why ask it?
1	Intro - thanks for time, intro to my PhD etc (focussed on development and politics of DH - how different interests/ideas influence policy, role of LAs). Clarify recording, use of data, who else I'm talking to. Consent form.	
2	Heat networks have had a higher profile in climate policy over the last 5 years. What are your views on the main drivers for this? Who have been the key actors in this?	For context on why the current focus on heat. Has the push come mainly from government or elsewhere?
3	Do you think the organisations involved in DH policy/development have changed over recent years? Which organisations have most influence? How do local authorities engage in DH policy debates and development?	Have any groups become more important over time. Explores key co-ordinating groups - where the influence is, who works together/competes. Do LAs work together or engage independently? Do they work with other actors?
4	A range of measures have been brought forward by government (and others) to support DH and CHP (list some of relevant country specific policies/activities). In your view is the current approach tackling the right things? What is missing? Should DH be regulated, if so how?	Allows discussion of whether some sort of legislation (i.e. Heat Act) or specific DH/CHP strategy is needed. Might touch on requirement to connect, consent regime, heat mapping, price regulation, mandating DH planning to local areas, lack of low cost finance etc - if they suggest these things ask how they think they should be delivered/managed (locally, centrally, other)
5	What are main challenges to DH development (might need to refer to possible topics e.g. financial issues, market issues, regulatory issues, policy, local powers)	Might be covered in 4 - if not use to prompt on issues of wider governance/institutional structures, role of sub-national powers in energy etc
6	What are the main areas for disagreement in DH policy - who disagrees?	Where are the sites of conflict - who's involved?
8	Do you think the HNDU is an effective approach to developing DH? Is their focus on LAs correct? (UK) / Do you think the current incentives for municipalities to engage in HNs are appropriate (Germany)?	Might be covered by 4 but if not allows discussion of value of feasibility funding/focus on LAs

9	DH is currently under diverse ownership and management structures in the UK/Germany (public/private/PPP/community ownership and differing splits of generation/distribution/supply). What are your views on which ownership structure might dominate going forward? Why?	Opener into lots of issues - LA ownership decision making on (based on RoR, risk, local politics and control). Finance issues - any probs with local access to appropriate finance? What extra benefits (or risks) does LA ownership bring?
10	How significant do you think the current increase in LA interest in involvement/ownership of energy infrastructure is? Follow on Qs…What might be the benefits/risks of more LA ownership/supply, what might it mean for policy? What are DH companies and the utilities saying about ownership?	Explore issues of local ownership and how this links to questions of the role of the local in the energy transition - will LAs take a strong role in DH regardless of government policy?
11	LAs currently largely decide on the level of involvement they want with DH development - is this the right approach? If not what needs to change?	Might be covered by 5 or 11 - if not allows discussion of whether there needs to be some sort of local powers/responsibility for heat planning and DH
12	Highlight researching is considering two country contexts and is interested in the interplay between local and national scales - do they have anything they want to say or things they think are important to explore?	

Appendix 4: Coding and analysis structure

Key: PO = policy idea, PR = programmatic ideas, PH = philosophical idea.





Actor networks and coalitions
Institutional practices in which discourses are produced
Coalitions and networks
Institutions linking local + national (PR)
Consumer groups (PO/PR)
Established vs emerging actor networks (PR/PH)
Civil Sociiety (PO/PR)
Role of industry bodies (PR)
Industry/public sector relations (PR/PH)
Coordination and consensus (PH)
Governance relationships
Discourse codification
Access to decisionmakers (PR/PH)
Scale and governance
Centralism/federalism (PH)
Local strategic energy planning (PR)
Formation of new organisations, policy, rules
Voluntary standards (PO)
Role of data (PO/PR)
Design of regulation (PO/PR)
HNDU/HNIP (PO/PR)
CHP support (PO/PR)
Remunicipalisation (PR/PH)
Difficulties facing new storylines (from dominant discourses)
DH 'fitting' in existing energy system (PR/PH)
Political interest in DH (PH)
Lack of local capacity to govern (PH)

References

ADE (2012) *CHPA presents “Big Offer” to Energy Secretary to boost community district heating*. Available at: https://www.theade.co.uk/news/press-releases/chpa-presents-big-offer-to-energy-secretary-to-boost-community-district-hea (Accessed: 12 January 2015).

ADE (2015) *Press Release: Industry response to Rip Off Britain*. London. Available at: https://www.theade.co.uk/news/press-releases/industry-response-to-rip-off-britain (Accessed: 15 September 2015).

ADE (2016) *Levelling the playing field: Unlocking heat infrastructure investment*. London, Association of Decentralised Energy.

ADE (2017a) *Consultation Response - Heat and Energy Efficiency Strategies, and Regulation of District Heating.* London, Association of Decentralisaed Energy.

ADE (2017b) *Heat Networks*. Available at: https://www.theade.co.uk/resources/what-is-district-heating (Accessed: 20 May 2017).

ADE (2017c) *Lightening the load carbon economy*. London, Association of Decentralisaed Energy.

ADE (2018a) *Market Report: Heat Networks in the UK*. London, Association of Decentralisaed Energy.

ADE (2018b) *Shared Warmth. A heat network market that benefits customers, investors, and the environment*. London, Association of Decentralisaed Energy.

AECOM and ETI (2017) *Reducing the capital cost of district heat network infrastructure. Routes to implement innovative solutions*. London.

Agora Energiewende (2013) *12 Insights on Germany’s Energiewende*. Berlin, Germany.

Agora Energiewende (2015a) *The European Power System in 2030: Flexibility Challenges and Integration Benefits*. Berlin, Germany.

Agora Energiewende (2015b) *The Role of CHP in the Energiewende - Die Rolle der Kraft- Wärme-Kopplung in der Energiewende Die Rolle der Kraft- der Energiewende*. Berlin, Germany.

Allmark, P. J. *et al.* (2009) ‘Ethical issues in the use of in-depth interviews :

literature review and discussion', *Research Ethics Review*, 5(2), pp. 48–54.
Almond, R. (2014) *The Energy Challenge for Cities - A Look at Sheffield*. Sheffield.
Andrews-Speed, P. (2016) 'Applying institutional theory to the low-carbon energy transition', *Energy Research and Social Science*, 13, pp. 216–225.
Andrews, D. *et al.* (2012) *Background Report on EU-27 District Heating and Cooling Potentials, Barriers, Best Practice and Measures of Promotion*. Petten, The Netherlands. doi: 10.2790/47209.
APSE (2013a) *APSE Facilitated Local Authority Energy Collaboration*. Manchester, Association of Public Service Excellence.
APSE (2013b) *The road to 2020: A manifesto for the Ensuring Council*. Manchester, Association of Public Service Excellence.
Archer, M. (1995) *Realist Social Theory: The Morphogenetic Approach*. Cambridge: Cambridge University Press.
Auer, J. and Anatolitis, V. (2014) *The Changing Energy Mix in Germany*. Frankfurt, DB Research, Deutsche Bank.
Auer, J. and Heymann, E. (2012) *Germany's energy turnaround*. Frankfurt, DB Research, Deutsche Bank.
Ayres, S., Flinders, M. and Sandford, M. (2018) 'Territory, power and statecraft: understanding English devolution', *Regional Studies*, 52(6).
Ayres, S. and Marsh, A. (2013) 'Reflections on contemporary debates in policy studies', *Policy & Politics*, 41(4), pp. 643–663.
Bache, Ian and Flinders, M. (2004) 'Multi-level Governance'. Oxford University Press, (March 2014), pp. 1–19. doi: 10.1093/0199259259.001.0001.
Bache, I. and Flinders, M. (2004) 'Multi-Level Governance and the Study of the British State', *Public Policy and Administration*, 19(1), pp. 31–51.
Bailey, S., Asenova, D. and Hood, J. (2012) 'The UK's Prudential Borrowing Framework: Professional Discipline and Control', *Local Government Studies*, 38(2), pp. 211–229. doi: 10.1080/03003930.2011.615832.
Bale, C. *et al.* (2014) 'Valuation of passive provisionfor heat network investments', in Brown, A. and Robertson, M. (eds) *Economic evaluation of systems of infrastructure provision: concepts, approaches, methods*. iBuild Project, University of Leeds.
Bale, C. S. E. *et al.* (2012) 'Strategic energy planning within local authorities in

the UK: A study of the city of Leeds', *Energy Policy*. Elsevier, 48, pp. 242–251. doi: 10.1016/j.enpol.2012.05.019.
Barton, J. *et al.* (2015) *Distributing Power - A transition to a civic energy future.* University of Leeds, Realising Transition Pathways Research Consortium 'Engine Room'.
BBC News (2001) *Demolition of 'worst incinerator in England'*, *BBC News*. Available at: http://news.bbc.co.uk/1/hi/uk/1408435.stm (Accessed: 3 March 2015).
BDEW (2015) *The Association*. Available at: https://www.bdew.de/internet.nsf/id/EN_About-us (Accessed: 19 August 2015).
Becker, S. (2017) 'Our city, our grid: The energy remunicipalisation trend in Germany', in Kishimoto, S. and Petitjean, O. (eds) *Reclaiming public services: How cities and citizens are turning back privatisation*. Amsterdam and Paris: Transnational Institute (TNI), pp. 117–128.
Becker, S., Beveridge, R. and Naumann, M. (2015) 'Remunicipalization in German cities: contesting neo-liberalism and reimagining urban governance?', *Space and Polity*, 19(1), pp. 76–90. doi: 10.1080/13562576.2014.991119.
Becker, S., Kouschil, K. and Naumann, M. (2014) 'Energy Poverty in Germany – Highlights of a Beginning Debate', *EU Fuel Poverty Network*, September.
Becker, S., Naumann, M. and Moss, T. (2016) 'Between coproduction and commons: understanding initiatives to reclaim urban energy provision in Berlin and Hamburg', *Urban Research & Practice*, 5069(March), pp. 1–23.
BEIS (2016a) *Energy Consumption in the UK*. London: Crown Copyright.
BEIS (2016b) *Heat Networks Investment Investment Project Consultation - Government Response*. London.
BEIS (2016c) *Heat Networks Investment Project Consultation - Government Response*. London: Crown Copyright.
BEIS (2016d) *Heat Networks Investment Project Pilot. Full Application Guidance*. London.
BEIS (2017a) *DUKES 2017. Chapter 7: Combined heat and power*. London: Crown Copyright.
BEIS (2017b) 'Energy Consumption in the UK (ECUK) 2017 Data Tables'. London: Department for Business, Energy and Industrial Strategy.
BEIS (2017c) *Heat Networks Consumer Survey. Results report.* London.

Available at: https://goo.gl/kzdp1h.
BEIS (2017d) *Heat Networks Investment Project. Results from the pilot.* London.
BEIS (2018a) *Evaluation of the Heat Networks Delivery Unit. Wave 2: Final Report*. London: Crown Copyright.
BEIS (2018b) *Heat Networks Investment Project Application Guidance*. London, BEIS. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/767662/heat-networks-investment-project-application-guidance.pdf.
BEIS (2018c) *Heat Networks Investment Project Scheme Overview*. London: Crown Copyright.
BEIS (2019) *Heat Networks Delivery Unit (HNDU): Overview*. Available at: https://www.gov.uk/guidance/heat-networks-delivery-unit (Accessed: 10 May 2019).
Béland, D. (2017) 'Kingdon Reconsidered: Ideas, Interests and Institutions in Comparative Policy Analysis', *Journal of Comparative Policy Analysis: Research and Practice*. Routledge, 18(3), pp. 228–242. doi: 10.1080/13876988.2015.1029770.
Bell, S. (2011) 'Do We Really Need a New "Constructivist Institutionalism" to Explain Institutional Change?', *British Journal of Political Science*, 41(4), pp. 883–906. doi: 10.1017/S0007123411000147.
Berkhout, F., Stirling, A. and Smith, A. (2004) 'Socio-technological regimes and transition contexts', *System innovation and the transition to sustainability: Theory, evidence and policy*, 44(106), pp. 48–75.
BERR, Defra and DCLG (2008) *Heat Call for Evidence*. London.
Beveridge, R. and Kern, K. (2014) *The Energiewende in Germany: Background, Developments and Future Challenges*.
Birmingham City Council (2007) *Birmingham Climate Change Strategy and Action Plan*. Birmingham.
Birmingham City Council (2010) *Climate change action plan 2010+*. Birmingham.
Birmingham City Council (2014) *From Waste to Resource A Sustainable Strategy for 2019*. Birmingham.

Blyth, M. (2002) ‘Institutions and Ideas’, in *Theory and Methods in Political Science*. 2nd edn. Basingstoke, UK: Palgrave Macmillan, pp. 292–310.
Blyth, M. (2006) ‘Great Punctuations: Prediction, Randomness, and the Evolution of Comparative Political Science’, *American Political Science Review*, 100(4), pp. 493–98.
BMU and BMWI (2010) *Energy Concept: for an Environmentally Sound, Reliable and Affordable Energy Supply*. Berlin, Germany.
BMUB (2014) *The German Government’s Climate Action Programme 2020*. Berlin, Germany.
BMWi (2010) *Energy Efficiency – Made in Germany. Energy Efficiency in Industry, Building Service Technology and Transport*. Berlin, Germany.
BMWi (2011) *Research for an environmentally sound, reliable and affordable energy supply. 6th Energy Research Programme of the Federal Government*. Berlin, Germany.
BMWi (2012) *Germany’s new energy policy*. Berlin, Germany.
BMWi (2014) *Report of the Federal Government on Energy Research 2014*. Berlin, Germany.
BMWi (2015a) *Energy Efficiency Strategy for Buildings*. Berlin, Germany, Germany.
BMWi (2015b) *The Energy of the Future. Fifth ‘Energy Transition’ Monitoring Report*. Berlin, Germany, Germany.
BMWi (2016) *Green Paper on Energy Efficiency*. Berlin, Germany, Germany.
Bohne, E. (2011) ‘Conflicts between national regulatory cultures and EU energy regulations’, *Utilities Policy*, 19(4), pp. 255–269. doi: 10.1016/j.jup.2011.05.003.
Bolton, R. (2011) *Socio-Technical Transitions and Infrastructure Networks: the cases of electricity and heat distribution in the UK*. University of Leeds.
Bolton, R. and Foxon, T. (2014) ‘Environmental Innovation and Societal Transitions A socio-technical perspective on low carbon investment challenges – Insights for UK energy policy’, *Environmental Innovation and Societal Transitions*. Elsevier B.V. doi: 10.1016/j.eist.2014.07.005.
Bolton, R. and Foxon, T. J. (2013) ‘Urban infrastructure dynamics: market regulation and the shaping of district energy in UK cities’, *Environment and Planning A*, 45(9), pp. 2194–2211. doi: 10.1068/a45575.
Bolton, R. and Foxon, T. J. (2014) ‘Infrastructure transformation as a socio-

technical process - Implications for the governance of energy distribution networks in the UK', *Technological Forecasting and Social Change*. Elsevier, 90, pp. 538–550. doi: 10.1016/j.techfore.2014.02.017.

Bolton, R. and Hannon, M. (2016) 'Governing sustainability transitions through business model innovation: Towards a systems understanding', *Research Policy*. Elsevier B.V., 45(9), pp. 1731–1742. doi: 10.1016/j.respol.2016.05.003.

Booth, P. (2015) *Federal Britain: The case for decentralisation*. London.

Bosman, R. *et al.* (2014) 'Discursive Regime Dynamics in the Dutch Energy Transition', *Environmental Innovation and Societal Transitions*. Elsevier B.V., 13, pp. 45–59. doi: 10.1016/j.eist.2014.07.003.

Boyce, C. and Neale, P. (2006) *Conducting In-Depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input*. Watertown, Massachusetts: Pathfinder International.

Bramah, M. (2014) *What will local government service provision look like in 2020?* Manchester, APSE.

BRE, University of Edinburgh and Centre for Sustainable Energy (2013) *Research into barriers to deployment of district heating networks*. London: Department of Energy and Climate Change.

Brenner, N., Peck, J. and Theodore, N. (2010) 'Variegated neoliberalization: Geographies, modalities, pathways', *Global Networks*, 10(2), pp. 182–222.

Bridge, G. *et al.* (2013) 'Geographies of energy transition: Space, place and the low-carbon economy', *Energy Policy*. Elsevier, 53, pp. 331–340.

Bristol City Council (2015a) *Climate and Energy Security Framework. Cabinet report. Agenda iten 10. 3 November 2015*. Bristol.

Bristol City Council (2015b) *Our Resilient Future: A Framework for Climate and Energy Security*. Bristol.

Bristol City Council (2016a) *Cabinet Report: Heat Networks Phase 2*. Bristol.

Bristol City Council (2016b) *New Mayor approves first major project towards 2050 carbon-neutrality goal*. Available at: http://news.bristol.gov.uk/new_mayor_approves_first_major_project_towards_2050 (Accessed: 7 June 2016).

Bristol Energy (2015) *Bristol Energy: a different type of energy company*. Available at: https://bristol-energy.co.uk/ (Accessed: 3 April 2017).

Bristol Energy (2017) *Council Ownership*. Available at: https://www.bristol-

energy.co.uk/about-us/council-ownership (Accessed: 3 April 2017).
Britton, J. (2015) *The Bristol Method: How to use heat networks to lower the carbon footprint of a city*. Bristol Green Capital.
Bröer, G. (2013) *Germany: Solar energy in district heating networks now stronger promoted*, *Solar District Heating*. Available at: http://www.solar-district-heating.eu/NewsEvents/News/tabid/68/ArticleId/244/Germany-Solar-energy-in-district-heating-networks-now-stronger-promoted.aspx (Accessed: 6 June 2013).
Bulkeley, H. (2000) 'Discourse coalitions and the Australian climate change policy network', *Environment and Planning C: Government and Policy*, 18(6), pp. 727–748. doi: 10.1068/c9905j.
Bulkeley, H. *et al.* (2016) 'Urban living labs: governing urban sustainability transitions', *Current Opinion in Environmental Sustainability*. Elsevier B.V., 22, pp. 13–17. doi: 10.1016/j.cosust.2017.02.003.
Bulkeley, H. and Betsill, M. (2005) 'Rethinking Sustainable Cities: Multilevel Governance and the "Urban" Politics of Climate Change', *Environmental Politics*, 14(1), pp. 42–63.
Bulkeley, H., Castan Broto, V. and Maassen, A. (2013) 'Low-carbon Transitions and the Reconfiguration of Urban Infrastructure', *Urban Studies*, 51(7), pp. 1471–1486.
Bulkeley, H. and Kern, K. (2006) 'Local Government and the Governing of Climate Change in Germany and the UK', *Urban Studies*, 43(12), pp. 2237–2259. doi: 10.1080/00420980600936491.
Bundeskartellamt (2012) *Final Report Sector Inquiry District Heating: Summary*. Berlin, Germany.
Bundeskartellamt (2015) *Bundeskartellamt and Stadtwerke Leipzig agree on lower prices for district heating*. Berlin, Germany.
Bundesnetzagentur and Bundeskertellamt (2017) *Bericht Monitoringbericht 2017*. Berlin, Germany.
Burnham, P. *et al.* (2008) *Research Methods in Politics*. Second Edi. Baskingstoke, Hampshire: Palgrave Macmillan.
Carbon Brief (2017) *Analysis: Just four years left of the 1.5C carbon budget*, *Carbon Brief*. Available at: https://www.carbonbrief.org/analysis-four-years-left-one-point-five-carbon-budget?ct=t(Carbon_Brief_Weekly_07_04_2017)

(Accessed: 5 April 2017).
Carbon Connect (2014) *Pathways for Heat: Low Carbon Heat for Buildings. Future Heat Series Part 1*. London.
Carbon Connect (2015) *Policy for Heat: Transforming the System. Future Heat Series Part 2*. London.
Carstensen, M. B. (2011a) 'Ideas are Not as Stable as Political Scientists Want Them to Be: A Theory of Incremental Ideational Change', *Political Studies*, 59, pp. 596–615.
Carstensen, M. B. (2011b) 'Paradigm man vs. the bricoleur: Bricolage as an alternative vision of agency in ideational change', *European Political Science Review*, 3(1), pp. 147–167..
Carstensen, M. B. and Schmidt, V. A. (2016) 'Power through, over and in ideas: conceptualizing ideational power in discursive institutionalism', *Journal of European Public Policy*. Taylor & Francis, 23(3), pp. 318–337.
Carvalho, S., Mingardo, G. and Haaren, J. V. A. N. (2012) 'Green Urban Transport Policies and Cleantech Innovations: Evidence from Curitiba, Goteborg and Hamburg', *European Planning Studies*, 20(3), pp. 375–396.
Castán Broto, V. (2017) 'Urban Governance and the Politics of Climate change', *World Development*, 93, pp. 1–15. doi: 10.1016/j.worlddev.2016.12.031.
Castán Broto, V. and Bulkeley, H. (2013) 'A survey of urban climate change experiments in 100 cities.', *Global environmental change : human and policy dimensions*, 23(1), pp. 92–102. doi: 10.1016/j.gloenvcha.2012.07.005.
Centre for Cities (2016) *UK cities need more autonomy to compete with European rivals*. Available at: http://www.centreforcities.org/blog/uk-cities-need-autonomy-compete-european-rivals/ (Accessed: 1 December 2016).
Chaudry, M. *et al.* (2014) *UKERC Energy Strategy Under Uncertainties: Uncertainties in UK heat infrastructure development*. UKERC/WP/FG/2014/005. Insitute of Energy, Cardiff University.
Chilvers, J. and Longhurst, N. (2012) *Participation, politics and actor dynamics in low carbon energy transitions. Report of a Transition Pathways Project workshop*. Norwich, University of East Anglia.
Chittum, A. and Østergaard, P. A. (2014) 'How Danish communal heat planning empowers municipalities and benefits individual consumers', *Energy Policy*. Elsevier, 74, pp. 465–474. doi: 10.1016/j.enpol.2014.08.001.

CHPA (2013) *Written evidence submitted by the Combined Heat and Power Association(HOT50). Energy and Climate Change Select Committee on Heat.* Available at: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/heat/written/1775.pdf.
CHPA (2014) *What is district heating?* Available at: http://www.chpa.co.uk/what-is-district-heating_191.html (Accessed: 12 November 2014).
CIBSE and ADE (2015) *Heat networks: Code of Practice for the UK. A guide for builders, owners and developers*. London, CIBSE.
Citizens Advice (2016) *District heating networks. Analysis of information request*. London.
City of Hamburg (2011) *The Hamburg Climate Action Plan*. Hamburg.
Climate KIC (2015) *Maximising Europe's Low Carbon Activities - Moving from individual projects to challenge-led, transition programmes*. Birmingham, EIT.
CODE2 Cogeneration Observatory and Dissemination Europe (2013) *D2.3 First draft of final CHP roadmap: Germany*. Brussels, Belgium.
Coenen, L. and Truffer, B. (2012) 'Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field', *European Planning Studies*, 20(3), pp. 367–374.
Committee on Climate Change (2010) *The Fourth Carbon Budget Reducing emissions through the 2020s*. London, CCC.
Committee on Climate Change (2013) *Fourth Carbon Budget Review – part 2*. London, CCC.
Committee on Climate Change (2014) *Meeting Carbon Budgets – 2014 Progress Report to Parliament*. London: The CCC.
Committee on Climate Change (2015a) *Meeting Carbon Budgets - Progress in reducing the UK's emissions. 2015 Report to Parliament*. London: Crown Copyright.
Committee on Climate Change (2015b) *Sectoral scenarios for the Fifth Carbon Budget*. London, CCC. Available at: https://d2kjx2p8nxa8ft.cloudfront.net/wp-content/uploads/2015/11/Sectoral-scenarios-for-the-fifth-carbon-budget-Committee-on-Climate-Change.pdf.
Committee on Climate Change (2016a) *Next steps for UK heat policy*. London.
Committee on Climate Change (2016b) *UK climate change following the Paris*

Agreement. London: The CCC. Available at: https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf.
Committee on Climate Change (2018) *Reducing UK emissions – 2018 Progress Report to Parliament*. London, CCC. Available at: https://www.theccc.org.uk/publication/reducing-uk-emissions-2018-progress-report-to-parliament/.
Competition and Markets Authority (2018) *Heat networks market study Final report*. London. Available at: www.nationalarchives.gov.uk/doc/open-government-.
Conaty, P. (2011) *A co-operative green economy: New solutions for energy and sustainable social justice*. Mancheste, Cooperatives UK.
Connolly, D. *et al.* (2014) 'Heat Roadmap Europe: Combining district heating with heat savings to decarbonise the EU energy system', *Energy Policy*. Elsevier, 65, pp. 475–489. doi: 10.1016/j.enpol.2013.10.035.
Connolly, D., Nielsen, S. and Persson, U. (2013) *Heat Roadmap Europe 2050*.
Connor, P. M. *et al.* (2015) 'The development of renewable heating policy in the United Kingdom', *Renewable Energy*. Elsevier Ltd, 75, pp. 733–744.
Core Cities Group (2013) *Step 6 : Power Up the Cities*. London.
Cowell, R., Ellis, G. and Strachan, P. A. (2017) 'Sub-national government and pathways to sustainable energy', *Politics and Space C*, 0(0), pp. 1–17.
Cox, K. R. (2010) 'The problem of metropolitan governance and the politics of scale', *Regional Studies*, 44(2), pp. 215–227.
Creswell, J. W. and Miller, D. L. (2000) 'Determining Validity in Qualitative Inquiry', *Theory Into Practice*, 39(3), pp. 124–130.
Cumbers, A. and McMaster, R. (2012) 'Rethinking public ownership and participation', *On the Horizon*, 20(3), pp. 172–181.
Danish Energy Agency (2017) *Regulation and planning of district heating in Denmark*. Copenhagen.
Danwitz, P. T. Von (2006) 'Regulation and Liberalisation of the European Electricity market', *Energy Law Journal*, 27, pp. 977–985.
Deas, I., Hincks, S. and Headlam, N. (2013) 'Explicitly permissive? Understanding actor interrelationships in the governance of economic development: The experience of England's Local Enterprise Partnerships',

Local Economy, 28(7–8), pp. 718–737. doi: 10.1177/0269094213500625.
DECC (2009a) *Heat and Energy Saving Strategy Consultation*. London: Crown Copyright.
DECC (2009b) *The UK Low Carbon Transition Plan: National strategy for climate and energy*. London: Crown Copyright: Department of Energy and Climate Change. Available at: https://www.gov.uk/government/publications/the-uk-low-carbon-transition-plan-national-strategy-for-climate-and-energy.
DECC (2011) *The Carbon Plan: Delivering our low carbon future*. London: Crown Copyright.
DECC (2012) *The Future of Heating : A strategic framework for low carbon heat in the UK*. London: Crown Copyright.
DECC (2013a) *Summary evidence on District Heating Networks in the UK*. London: Department of Energy and Climate Change.
DECC (2013b) *The Future of Heating: Meeting the challenge*. London: Crown Copyright.
DECC (2013c) *Written evidence submitted by the Department of Energy and Climate Change (HOT51) Energy and Climate Change Select Committee on Heat.* London, HM Government. Available at: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/heat/written/1792.pdf.
DECC (2014a) *Community Energy Strategy: Full Report*. London: Department of Energy and Climate Change.
DECC (2014b) *Funding boost for low carbon heating*. London. Available at: https://www.gov.uk/government/news/funding-boost-for-low-carbon-heating (Accessed: 26 March 2014).
DECC (2015a) *Assessment of the Costs , Performance, and Characteristics of UK Heat Networks*. London: Department of Energy and Climate Change.
DECC (2015b) *Call for Evidence: Tackling Non- Financial Barriers to Gas CHP*. London: Crown Copyright.
DECC (2015c) *Delivering UK Energy Investment: Networks*. London: Crown Copyright.
DECC (2015d) *Department of Energy and Climate Change's settlement at the Spending Review 2015: Press release*. London: Department of Energy and Climate Change.

DECC (2015e) *Evaluation of the Heat Networks Delivery Unit: Interim report covering wave 1 research*. London: Crown Copyright.
DECC (2015f) *Investing in the UK's heat infrastructure: Heat Networks*. London: Department of Energy and Climate Change.
DECC (2016) *Consultation on ensuring regulation encourages innovation*. London: Crown Copyright.
Denscombe, M. (2010) *The Good Research Guide: for small-scale social research projects*. Open University Press.
Department of Communities and Local Government (2008) *Practical use of the Well-Being Power*. London: DCLG.
Deutsch Umwelthilfe (2017) *Sector coupling: Using electricity for heating and transport to protect the climate*. Berlin, Germany.
DiMaggio, P. J. and Powell, W. W. (1991) 'Introduction', in *The New Institutionalism in Organizational Analysis*, pp. 1–40. doi: 10.2307/258726.
Dodd, N. (2008) *Community Energy: Urban Planning for a Low Carbon Future*. London.
Dodson, J. (2013) 'Suburbia under an Energy Transition: A Socio-technical Perspective', *Urban Studies*, 51(7), pp. 1487–1505.
Dryzek, J. (2005) *The Politics of the Earth: Environmental Discourses*. Oxford University Press.
Eichler, M. (2016) *Bio-Energy Villages in Germany A Comparison of decentralized, rural Energy Systems*. University of Twente.
Element Energy (2015) *Research on district heating and local approaches to heat decarbonisation. A study for the Committee on Climate Change*. London, CCC.
Element Energy and E4tech (2018) *Cost analysis of future heat infrastructure options. Report for the National Infrastructure Commission*. Cambridge, Element Energy. Available at: https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf.
Elexon (2013) *The Electricity Trading Arrangements: a Beginners Guide*. London: Elexon.
Emden, J., Aldridge, J. and Orme, B. (2017) *Piping Hot. The opportunity for heat networks in a new industrial strategy*. London: IPPR.

Energiereferat Stadt Frankfurt am Main (2008) *Energy action plan and CO 2 inventory for Frankfurt am Main*. Frankfurt am Main.
Energy and Climate Change Committee (2016) *2020 renewable heat and transport targets. Second report of Session 2016-17*. London, HM Government.
Energy Saving Trust (2017) *Air source heat pumps*. Available at: http://www.energysavingtrust.org.uk/renewable-energy/heat/air-source-heat-pumps (Accessed: 3 February 2017).
Energy Technologies Institute (2012) *ETI Macro Distributed Energy Project: Summary Report*. Loughborough, ETI.
Energy Transition (2012) *Energy Transition*. Available at: http://energytransition.de (Accessed: 19 October 2015).
Ericsson, K. (2009) *Introduction and development of the Swedish district heating systems: Critical factors and lessons learned*. D5 of WP2. Lund University, RES-H Policy Project. D5 of WP2.
Eurelectric (2014) *CHP as part of the energy transition. The way forward*. Brussels.
Euroheat and Power (2013) *District heating and Cooling Country by Country survey*. Brussels.
Euroheat and Power (2015) *Country by Country statistics overview*. Brussels, Belgium.
European Commission (2012) *Energy Roadmap 2050*. Brussels, Belgium. Available at: http://www.roadmap2050.eu/.
European Commission (2016) *An EU Strategy on Heating and Cooling*. Brussels, Belgium, Belgium.
Eurostat (2017) ‘Energy from renewable sources’. Brussels, Belgium: European Commission. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_from_renewable_sources.
EWI and Prognos (2005) *The Trend of Energy Markets up to the Year 2030. Reference Forecast for the Energy Sector Energy Report IV – Summary*. Berlin.
Eyre, N. and Baruah, P. (2014) *UK Energy Strategies Under Uncertainty: Uncertainties in Energy Demand in Residential Heating*. University of Oxford, UKERC.
Fay, P. (2013) *Sustainable Energy Action Plan Frankfurt am Main*. Frankfurt am Main.

Federal Environment Office (2017) *Indicator: Combined heat and power (CHP) 2003 -2016*. Available at: https://www.umweltbundesamt.de/en/indicator-combined-heat-power-chp#textpart-1 (Accessed: 2 February 2018).
Federal Minstry for Economic Affairs and Energy (2014) *Making more out of energy: National Action Plan on Energy Efficiency*. Berlin, Germany.
Feindt, P. H. and Oels, A. (2005) 'Does discourse matter? Discourse analysis in environmental policy making', *Journal of Environmental Policy & Planning*, 7(3), pp. 161–173. doi: 10.1080/15239080500339638.
Fischer, F. (2003) *Reframing Public Policy. Discursive Politics and Deliberative Practices.* Oxford, Oxford University Press.
Fleck, B. (2015) *Rhein-Hunsrück District - from energy importer to energy exporter!* Rhein-Hunsrück.
Flick, U., von Kardoff, E. and Stienke, I. (2004) *A companion to Qualitative Research*. London: Sage Publications.
Flyvbjerg, B. (1998) *Rationality and Power: Democracy in Practice*. Translated. Chicago: University of Chicago Press.
Flyvbjerg, B. (2006) 'Five Misunderstandings About Case-Study Research', *Qualitative Inquiry*, 12(2), pp. 219–245. doi: 10.1177/1077800405284363.
Forsyth, I. (2014) *Cofely District Energy Presentation to CHP Conference*. Cofely District Energy Ltd.
Foxon, T. J. (2011) 'A co-evolutionary framework for analysing a transition to a sustainable low carbon economy', *Ecological Economics*. Elsevier B.V., 70(12), pp. 2258–2267. doi: 10.1016/j.ecolecon.2011.07.014.
Friedel, W. (2010) *Implementing decentralized co-generation: The Frankfurt case study*. Frankfurt am Main.
Friedländer, B. (2013) *Rekommunalisierung öffentlicher Dienstleitungen: Konzept - Entwicklungstendenzen - Perspektive*. 45. Leipzig.
Friends of the Earth (2011) *FAQs: The new Nottingham Declaration on climate change*. London.
Frontier Economics (2015) *Research on district heating and local approaches to heat decarbonisation. Annex 1: Overcoming barriers to district heating*. London, CCC.
Fuchs, G. and Hinderer, N. (2014) 'Sustainable electricity transitions in Germany in a spatial context: between localism and centralism', *Urban,*

Planning and Transport Research, 2(February 2015), pp. 354–368.
Fuchs, G. and Hinderer, N. (2016) ‘One or many transitions: local electricity experiments in Germany’, *The European Journal of Social Science Research*. Taylor & Francis, 29(3), pp. 320–336. doi: 10.1080/13511610.2016.1188683.
Fudge, S., Peters, M. and Wade, J. (2012) *Locating the agency and influence of local authorities in UK energy governance*. Centre for Environmental Strategy Working Paper 01/12. Guildford, University of Surrey.
Fudge, S., Peters, M. and Woodman, B. (2016) ‘Environmental Innovation and Societal Transitions Local authorities as niche actors: the case of energy governance in the UK’, *Environmental Innovation and Societal Transitions*, 18, pp. 1–17. doi: 10.1016/j.eist.2015.06.004.
Fuenfschilling, L. and Truffer, B. (2014) ‘The structuration of socio-technical regimes—Conceptual foundations from institutional theory’, *Research Policy*. Elsevier B.V., 43(4), pp. 772–791. doi: 10.1016/j.respol.2013.10.010.
Fürniß, J. (2012) *ESCO business at Mainova*. Frankfurt am Main.
Gailing, L. and Röhring, A. (no date) ‘Germany’s Energiewende and the Spatial Reconfiguration of an Energy System’, in Gailing, L. and Moss, T. (eds) *Germany’s Energiewende and the Spatial Reconfiguration of an Energy System*. London: Palgrave Macmillan, pp. 11–20.
Le Gales, P. and Scott, a (2010) ‘A British Bureaucratic Revolution? Autonomy Without Control, or “Freer Markets, More Rules”’, *Revue Francaise De Sociologie*, 51, pp. 117–143.
Gamble, A. (1995) ‘The New Political Economy’, *Political Studies*, 43(3), pp. 516–530.
Garnett, M. and Lynch, P. (2009) *Exploring British Politics*. 2nd Editio. Harlow, Essex: Pearson Education.
Geels, F. W. (2002) ‘Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study’, *Research Policy*, 31(8–9), pp. 1257–1274. doi: 10.1016/S0048-7333(02)00062-8.
Geels, F. W. (2004) ‘From sectoral systems of innovation to socio-technical systems’, *Research Policy*, 33(6–7), pp. 897–920.
Geels, F. W. (2005) ‘Co-evolution of technology and society: The transition in water supply and personal hygiene in the Netherlands (1850–1930)—a case study in multi-level perspective’, *Technology in Society*, 27(3), pp. 363–397.

Geels, F. W. (2010) 'Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective', *Research Policy*. Elsevier B.V., 39(4), pp. 495–510. doi: 10.1016/j.respol.2010.01.022.

Geels, F. W. (2011) 'The multi-level perspective on sustainability transitions: Responses to seven criticisms', *Environmental Innovation and Societal Transitions*. Elsevier B.V., 1(1), pp. 24–40. doi: 10.1016/j.eist.2011.02.002.

Geels, F. W. (2012) 'A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies', *Journal of Transport Geography*. Elsevier Ltd, 24, pp. 471–482.

Geels, F. W. (2013) 'The impact of the financial–economic crisis on sustainability transitions: Financial investment, governance and public discourse', *Environmental Innovation and Societal Transitions*, (6), pp. 67–95.

Geels, F. W. (2014) 'Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective', *Theory, Culture & Society*. doi: 10.1177/0263276414531627.

Geels, F. W. *et al.* (2016) 'The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014)', *Research Policy*. Elsevier B.V., 45(4), pp. 896–913. doi: 10.1016/j.respol.2016.01.015.

Geels, F. W., Hekkert, M. P. and Jacobsson, S. (2008) 'The dynamics of sustainable innovation journeys', *Technology Analysis & Strategic Management*, 20(5), pp. 521–536.

Geels, F. W. and Schot, J. (2007) 'Typology of sociotechnical transition pathways', *Research Policy*, 36(3), pp. 399–417.

Gerring, J. (2004) 'What Is a Case Study and What Is It Good for?', *American Political Science Review*, 98(02), pp. 341–354.

Giddens, A. (2003) 'Introduction. Neoprogressivism. A new agenda for social democracy.', in Giddens, A. (ed.) *The Progressive Manifesto*. Cambridge: Polity Press, p. 134.

Gillard, R. (2016) 'Unravelling the United Kingdom's climate policy consensus: The power of ideas, discourse and institutions', *Global Environmental Change*. Elsevier Ltd, 40, pp. 26–36. doi: 10.1016/j.gloenvcha.2016.06.012.

Gofas, A. and Hay, C. (2010) 'The ideational turn and the persistence of perennial dualisms', in Gofas, A. and Hay, C. (eds) *The role of ideas in political* *analysis: a portrait of contemporary debates*. First Edit. Abingdon, Oxford.: Routledge, pp. 3–10.

Golbach, A. (2012) *German Policy and Market Update*. Cogen Europe Webinar 20th September 2012, KWK Kommt.

Gouldson, A. *et al.* (2012) *The Economics of Low Carbon Cities: A Mini-Stern Review for the Sheffield City Region*. University of Leeds.

Greater Manchester Combined Authority (2017) *DEPA (District Energy Procurement Agency)*. Available at: https://www.greatermanchester-ca.gov.uk/info/20005/green_city_region/116/low_carbon_project_delivery_unit/5 (Accessed: 17 November 2018).

Green Investment Bank (2015) *Smart, greener cities: Ten ways to modernise and improve UK urban infrastructure*. Edinburgh.

Griffiths, S. and Kippin, H. (2017) 'Public Services after Austerity: Zombies , Suez or Collaboration?', *Political Quarterly*, 88(3), pp. 417–424.

Habermas, J. (1987) *Lifeworld and System: A Critique of Functionalist Reason, volume 2 of The Theory of Communicative Action*. Translatio. Boston: Boston: Beacon Press.

Hajer, M. (1995a) *The politics of environmental discourse: Ecological modernization and the policy process*, *Global Environmental Change*. Oxford, Oxford University Press. doi: 10.1016/S0959-3780(97)82909-3.

Hajer, M. (1995b) *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford: Oxford University Press.

Hajer, M. (2005) 'Coalitions, practices, and meaning in environmental politics: from acid rain to BSE', in Howarth, D. and Torfing, J. (eds) *Discourse theory in European politics: identity, policy and governance*. Basingstoke: Palgrave Macmillan, pp. 297–315.

Hajer, M. (2006) 'Doing discourse analysis: coalitions, practices, meaning', in van den Brink, M. and Metze, T. (eds) *Words matter in policy and planning: discourse theory and method in the social sciences*. Utrecht: Netherlands Geographical Studies 344, pp. 65–74.

Hajer, M. and Versteeg, W. (2005) 'A decade of discourse analysis of environmental politics: Achievements, challenges, perspectives', *Journal of Environmental Policy & Planning*, 7(3), pp. 175–184.

Hall, D. (2003) *Public Services Work! Information, Insights and ideas for our*

future. University of Greenwich, Public Services International.
Hall, D., Lobina, E. and Terhorst, P. (2013) ‘Re-municipalisation in the early twenty-first century: water in France and energy in Germany’, *International Review of Applied Economics*, 27(2), pp. 193–214.
Hall, P. A. (1986) *Governing the Economy: The Politics of State Intervention in Britain and France*. Oxford University Press.
Hall, P. A. (1993) ‘Policy Paradigms, Social Learning, and the State. The Case of Economic Policymaking in Britain’, *Comparative Politics*, 25(3), pp. 275–296.
Hall, P. A. and Taylor, R. C. R. (1996) ‘Political Science and the Three New Institutionalisms’, *Political Studies*, 44, pp. 936–957.
Hall, S. and Foxon, T. J. (2014) ‘Values in the Smart Grid: the co-evolving political economy of smart distribution’, *Energy Policy*. Elsevier, 74, pp. 600–609. doi: 10.1016/j.enpol.2014.08.018.
Hall, S., Foxon, T. J. and Bolton, R. (2014) ‘The new’civic’ energy sector: implications for ownership, governance and financing of low carbon energy infrastructure’, in *BIEE 2014*.
Hall, S., Foxon, T. J. and Bolton, R. (2015) *The new ‘ civic ’ energy sector : civil society institutions and energy infrastructure transitions in Germany and the UK*. 2015/1.
Hall, S., Foxon, T. J. and Bolton, R. (2016) ‘Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom’, *Energy Research and Social Science*. Elsevier Ltd, 12, pp. 5–15.
Hall, T. and Hubbard, P. (1996) ‘The entrepreneurial city: new urban politics, new urban geographies?’, *Progress in Human Geography*, 20(2), pp. 153–174.
Hamburg Institut Research GmbH (2015) *Fernwärme 3.0: Strategien für eine zukunftsorientierte Fernwärmepolitik*. Hamburg, Germany.
Hannon, M. J. and Bolton, R. (2015) ‘UK Local Authority engagement with the Energy Service Company (ESCo) model: Key characteristics, benefits, limitations and considerations’, *Energy Policy*. Elsevier, 78, pp. 198–212.
Hansen, T. and Coenen, L. (2015) ‘The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field’, *Environmental Innovation and Societal Transitions*, 17, pp. 92–109.
Hardy, P. (2015) *COP21 ambitions can only be delivered by market disruptions in residential heating markets*. Available at: https://www.delta-ee.com/delta-ee-

blog/cop21-ambitions-can-only-be-delivered-by-market-disruptions-in-residential-heating-markets.html (Accessed: 4 December 2015).
Hargreaves, T., Longhurst, N. and Seyfang, G. (2012) *Understanding sustainability innovations: points of intersection between the multi-level perspective and social practice theory*, *3S Working Paper 2012-03*. Norwich, University of East Anglia.
Harkin, S., Dwyer, S. and Bradley, A. (2013) *Is Germany in the slow lane for low carbon heat ?* Delta Energy and Environment.
Harvey, D. (1989) 'From Managerialism to entrepreneurialism: The Transformation in Urban Governane in Late Capitalism', *Geografiska Annaler. Series B, Human Geography*, 71(1), pp. 3–17.
Hawkey, D. (2009) *Will "District Heating Come To Town?" Analysis Of Current Opportunities And Challenges In The UK*. University of Edinburgh.
Hawkey, D. (2012) *District Heating UK Local Authorities' Vanguard Network – response to DECC Heat Strategy Consultation 2012*. University of Edinburgh.
Hawkey, D. (2013) *Written evidence submitted by RCUK Heat and the City Project, University Of Edinburgh (HOT39). Energy and Climate Change Select Committee on Heat.* Available at: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/heat/written/1657.pdf.
Hawkey, D. J. C. (2012) 'District heating in the UK: A Technological Innovation Systems analysis', *Environmental Innovation and Societal Transitions*. Elsevier B.V., 5, pp. 19–32. doi: 10.1016/j.eist.2012.10.005.
Hawkey, D. and Webb, J. (2012) 'Multi-level Governance of Socio-Technical Innovation: the Case of District Heating in the UK', in *Paper presented at Jean Monnet International Workshop: The Governance of Innovation and Socio-Technical Systems in Europe: New Trends, New Challenge, CBS, March 1-2 2012.*, pp. 1–23.
Hawkey, D. and Webb, J. (2014) 'District energy development in liberalised markets: situating UK heat network development in comparison with Dutch and Norwegian case studies', *Technology Analysis and Strategic Management*, 26(10), pp. 1228–1241.
Hawkey, D., Webb, J. and Winskel, M. (2013) 'Organisation and governance of urban energy systems: district heating and cooling in the UK', *Journal of*

Cleaner Production. Elsevier Ltd, 50, pp. 22–31.
Hay, C. (2002) *Political Analysis: A Critical Introduction*. Basingstoke, UK: Palgrave Macmillan.
Hay, C. (2008) 'Constructivist Institutionalism', in Rhodes, R. A. W., Binder, S. A., and Rockman, B. A. (eds) *The Oxford Handbook of Political Institutions*. Oxford University Press, pp. 56–74.
Hay, C. and Wincott, D. (1998) 'Structure, Agency and Historical Institutionalism', *Political Studies*, 4, pp. 951–957.
Heat and the City Project (2011) *Developing District Heating in the UK: What Works?*
Heat and the City Project (2015) *District Energy Vanguards Network Newsletter - Issue 21*. Edinburgh.
Heat and the City Project (2017) *District Energy Vanguards Newsletter - Dec 2016/January 2017*. 41. University of Edinburgh.
Heat Roadmap Europe 2050 (2017a) *2015 Final Heating & Cooling Demand in the Germany - Country presentation*. Brussels, Belgium. Available at: http://www.heatroadmap.eu/resources/HRE4-Country_presentation-Germany.pdf.
Heat Roadmap Europe 2050 (2017b) *Heat and Cooling: facts and figures.* Brussels, Belgium.
Heat Trust (2015) *Heat Trust Scheme Rules*. London, ADE.
Heddenhausen, M. (2007) *Privatisations in Europe's liberalised electricity markets – the cases of the United Kingdom, Sweden, Germany, and France*. German Institute for International and Security Affairs, Berlin.
Van Der Heijden, J. (2010) 'A short history of studying incremental institutional change: Does Explaining Institutional Change provide any new explanations?', *Regulation and Governance*, 4(2), pp. 230–243.
Helm, D. (2010) 'The role of the government and the private sector in the current world', in *European Investment Bank Papers, 15 (2)*.
Hendriks, C. M. and Grin, J. (2007) 'Contextualizing Reflexive Governance: the Politics of Dutch Transitions to Sustainability', *Journal of Environmental Policy & Planning*, 9(3–4), pp. 333–350. doi: 10.1080/15239080701622790.
Henning, D. and Mårdsjö, O. (2010) 'Barriers to district heating development in some European Countries', in *12th International Symposium on District Heating*

and Cooling. Tallinn, Estonia, pp. 223–228.
Hers, S. *et al.* (2015) *Potential for Power-to-Heat in the Netherlands*. Delft, The Netherlands.
Herzberg, C. (2013) 'Autonomisation and Democratic Control: A Typology for Public Utilities in Remunicipalisation Processes.', in *7th ECPR General Conference, Panel 266 Privatisation and Pricing in Water Supply and Treatment. 4th-7th September 2013, Boreaux, France*, pp. 1–22.
Hess, D. J. (2014) 'Sustainability transitions: A political coalition perspective', *Research Policy*. Elsevier B.V., 43(2), pp. 278–283.
Hetherington, P. (2013) 'Councils generate own power to take on the big six energy firms', *Guardian*, 4 December. Available at: http://www.theguardian.com/society/2013/dec/04/councils-generate-own-power-big-six-energy-fuel-poverty.
Hewitt, S. (2009) *Discourse Analysis and Public Policy Research*. 24. Centre for Rural Economy, Newcastle University.
Hill, M. (2009) *The Public Policy Process*. 5th edn. Harlow: Pearson Longman.
HM Government (2007) *Meeting the Energy Challenge. A White Paper on Energy*. London: Crown Copyright.
HM Government (2011) 'A plain English guide to the Localism Act', (London: Crown Copyright).
HM Government (2017) *The Clean Growth Strategy: Leading the way to a low carbon future*. London: Crown Copyright.
HM Treasury (2013) *National Infrastructure Plan 2013*. London, HM Government.
HNDU (2015) *The Future of Heat in the UK: the UK's vision for heat networks*. London: Department of Energy and Climate Change.
Hodson, M., Evans, J. and Schliwa, G. (2018) 'Conditioning experimentation: The struggle for place-based discretion in shaping urban infrastructures', *Environment and Planning C: Politics and Space*, 0(0), pp. 1–19.
Hodson, M., Geels, F. W. and Mcmeekin, A. (2017) 'Reconfiguring Urban Sustainability Transitions , Analysing Multiplicity', *Sustainability*, 9(2), pp. 299–319. doi: 10.3390/su9020299.
Hodson, M. and Marvin, S. (2010) 'Can cities shape socio-technical transitions and how would we know if they were?', *Research Policy*. Elsevier B.V., 39(4),

pp. 477–485. doi: 10.1016/j.respol.2010.01.020.
Hodson, M. and Marvin, S. (2012) ‘Mediating Low-Carbon Urban Transitions? Forms of Organization, Knowledge and Action’, *European Planning Studies*, 20(3), pp. 421–439. doi: 10.1080/09654313.2012.651804.
Hodson, M. and Marvin, S. (2016) ‘The mutual construction of urban retrofit and scale: Governing ON, IN and WITH in Greater Manchester’, *Environment and Planning C: Government and Policy*, 0(0), pp. 1–20.
Hodson, M., Marvin, S. and Bulkeley, H. (2013) ‘The Intermediary Organisation of Low Carbon Cities: A Comparative Analysis of Transitions in Greater London and Greater Manchester’, *Urban Studies*, 50(7), pp. 1403–1422.
Hoggett, R., Ward, J. and Mitchell, C. (2011) *Heat in Homes: customer choice on fuel and technologies. Study for Scotia Gas Networks*. University of Exeter, Energy Energy Policy Group.
Homes and Communities Agency (2011) *District Heating Good Pracice: Learning from the Low Carbon Infrastructure Fund*. London.
Hommels, A. (2005) ‘Studying Obduracy in the City: Toward a Productive Fusion between Technology Studies and Urban Studies’, *Science, Technology & Human Values*, 30(3), pp. 323–351. doi: 10.1177/0162243904271759.
Hood, C. (1995) ‘The “new public management” in the 1980s: Variations on a theme’, *Accounting, Organizations and Society*, 20, pp. 93–109.
Hooghe, L. and Marks, G. (2003) *Unraveling the Central State, But How? Types of Multi-Level Governance*. Institute for Advanced Studies, Vienna.
Hughes, T. P. (1983) *Networks of power: electrification in Western society, 1880-1930.* Baltimore, Maryland, USA: Johns Hopkins University Press.
Huther, H. (2010) *The prospect of district heating and district heating research in Germany*. 12th International Symposium of District Heating and Cooling.
IEA (2010) *CHP/DHC Country Scorecard: United Kingdom*. Paris, France.
IEA (2015) *Energy and Climate Change. World Energy Outlook Special Report*. Paris, France. doi: 10.1038/479267b.
Infrastructure and Projects Authority (2016) *National Infrastructure Delivery Plan 2016 – 2021 National*. London: HM Treasury and Cabinet Office.
Intelligent Energy Europe Programme (2014) *Overview of projects on energy efficient and renewable HEATING and COOLING supported under the Intelligent Energy Europe programme 2010-2013*. Brussels, Belgium.

International Energy Agency (2004) *Coming in from the cold. Improving district heating policies in transition economies.* Paris, France.
International Energy Agency (2009) *CHP/DHC Country Scorecard: CHP Status : Technology , Applications and Market Activity*. Paris, France.
International Energy Agency (2012) *Energy Technology Perspectives 2012*. Paris, France.
International Energy Agency (2013) *Germany - 2013 Review: Executive Summary*. Paris, France.
International Energy Agency (2014a) *Heating without global warming. Market Developments and Policy Considerations for Renewable Heat*. Paris, France.
International Energy Agency (2014b) *Linking Heat and Electricity Systems. Co-generation and District Heating and Cooling Solutions for a Clean Energy Future*. Paris, France.
International Energy Agency (2018) *Global Energy & CO2 Status Report 2017*. Paris, France.
Jansen, D. (2011) 'Local Utilities in the German Electricity Market and Their Role in the Diffusion of Innovations in Energy Efficiency and Climate Change Mitigation', in Jansen, D., Ostertag, K., and Walz, R. (eds) *Sustainability Innovations in the Electricity Sector.* London: Springer.
Jenssen, T., König, A. and Eltrop, L. (2014) 'Bioenergy villages in Germany: Bringing a low carbon energy supply for rural areas into practice', *Renewable Energy*. Elsevier, 61, pp. 74–80. doi: 10.1016/j.renene.2012.08.014.
Jones, G. and Stewart, J. (2012) 'Local government: the past, the present and the future', *Public Policy and Administration*, 27(4), pp. 346–367.
Jörgensen, K. (2012) 'Governance for Sustainable Development in the German Budesländer', in Bruyninckx, H., Happaerts, S., and Van den Brande, K. (eds) *Sustainable Development and Subnational Governments: Policy-Making and Multi-Level Interactions*. Basingstoke, UK: Palgrave.
Julian, C. (2014) *Creating Local Energy Economies: Lessons from Germany*. London, ResPublica.
Just, S. (2015) *The German market for system reserve capacity and balancing energy*. EWL Working Paper, No. 06/15. Essen.
Kelly, S. and Pollitt, M. (2010) 'An assessment of the present and future opportunities for combined heat and power with district heating (CHP-DH) in the

United Kingdom', *Energy Policy*. Elsevier, 38(11), pp. 6936–6945.
Kemfert, B. C. and Horne, J. (2013) *Good Governance of the Energiewende in Germany: wishful thinking or manageable?* Berlin, Hertie School of Governance.
Kern, F. (2009) *The politics of governing 'system innovations' towards sustainable electricity systems*. University of Sussex.
Kern, F. (2011) 'Ideas, institutions, and interests: explaining policy divergence in fostering "system innovations" towards sustainability', *Environment and Planning C: Government and Policy*, 29(6), pp. 1116 – 1134.
Kern, F., Kuzemko, C. and Mitchell, C. (2014) 'Measuring and explaining policy paradigm change: the case of UK energy policy', *Policy & Politics*, 42(4), pp. 513–530. doi: 10.1332/030557312X655765.
Kern, K. and Bulkeley, H. (2009) 'Cities, Europeanization and Multi-level Governance: Governing Climate Change through Transnational Municipal Networks', *JCMS: Journal of Common Market Studies*, 47(2), pp. 309–332.
King, M. (2015) *District Energy Vanguards Newsletter. Issue 29 - October 2015*.
King, M. (2016) 'Editorial: Standing high?', *District Energy Vanguards Newsletter November 2016*, November, pp. 1–10. Available at: http://www.heatandthecity.org.uk/__data/assets/pdf_file/0003/216732/DEVN_41_-_November_2016_-_updated.pdf.
Kingdon, J. (1995) *Agendas, Alternatives and Public Policies*. 2nd Editio. New York: Harper Collins.
Koelble, T. A. (2014) 'The New Institutionalism in Political Science and Sociology', *Comparative Politics*, 27(2), pp. 231–243.
KPMG LLP (2015) *UK solar beyond subsidy: the transition*. London.
Kuzemko, C. (2013a) *The Energy Security-Climate Nexus: Institutional Change in the UK and Beyond.* Hampshire and New York: Palgrave Macmillan.
Kuzemko, C. (2013b) *Understanding the Politics of Low Carbon Transition: Context , Paradigms and Power*. 1301. Energy Policy Group, University of Exeter.
Kuzemko, C. (2014) *Blog from Berlin – Part Zwei: Why Culture and Institutions Matter in Low Carbon Transformations*, *iGov New Thinking for Energy Blog*. Available at: http://projects.exeter.ac.uk/igov/blog-from-berlin-part-zwei-why-culture-and-institutions-matter-in-low-carbon-transitions/ (Accessed: 11

September 2014).
Kuzemko, C. *et al.* (2017) ‘Energy Research & Social Science Policies , politics and demand side innovations: The untold story of Germany’s energy transition’, *Energy Research & Social Science*. Elsevier, 28(February), pp. 58–67.
Lancaster, K. (2017) ‘Confidentiality , anonymity and power relations in elite interviewing : conducting qualitative policy research in a politicised domain politicised domain’, *International Journal of Social Research Methodology*. Routledge, 20(1), pp. 93–103. doi: 10.1080/13645579.2015.1123555.
Lawhon, M. and Murphy, J. T. (2011) ‘Socio-technical regimes and sustainability transitions: Insights from political ecology’, *Progress in Human Geography*, 36(3), pp. 354–378. doi: 10.1177/0309132511427960.
Lehr, N., Kondziella, H. and Bruckner, T. (2014) ‘Potential of the Power-to-Heat Technology in District Heating Grids in Germany’, *Energy Procedia*, 46, pp. 246–253. doi: 10.1016/j.egypro.2014.01.179.
Lets Recycle (2017) *Sheffield councillors vote to end 35-year Veolia contract*, *Lets Recycle*. Available at: https://www.letsrecycle.com/news/latest-news/sheffield-councillors-vote-to-end-35-year-veolia-contract/ (Accessed: 19 January 2017).
Libbe, J. (2008) ‘Infrastructure Planning as a Local Government Task: Current Challenges and Needs’, *German Journal of Urban Studies*, 2(138).
Local Government Association (2018) *LGA Devolution Register*. London.
Lockwood, M. *et al.* (2016) ‘Historical institutionalism and the politics of sustainable energy transitions: A research agenda’, *Environment and Planning C: Government and Policy*, 0(0), pp. 1–22. doi: 10.1177/0263774X16660561.
Loorbach, D. (2007) *Transition Management. New Mode of Governance for Sustainable Development.* Utrecht, Netherlands: International Books.
Lorenzoni, I. and Benson, D. (2014) ‘Radical institutional change in environmental governance: Explaining the origins of the UK Climate Change Act 2008 through discursive and streams perspectives’, *Global Environmental Change*. Elsevier Ltd, 29, pp. 10–21. doi: 10.1016/j.gloenvcha.2014.07.011.
Lovell, H. and Bulkeley, H. (2009) ‘Converging agendas? Energy and climate change policies in the UK.’, *Environment and Planning C: Government and Policy*, 27, pp. 90–109.
Low Carbon Innovation Coordination Group (2012) *Technology Innovation*

Needs Assessment (TINA) Heat Summary Report. London, DECC.
Lowndes, V. (1996) ‘Varieties of new institutionalism: a critical appraisal’, *Public Administration*, 74, pp. 181–197.
Lowndes, V. (2010a) ‘The Institutional Approach’, in Marsh, D. and Stoker, G. (eds) *Theory and Methods in Political Science*. Basingstoke: Palgrave Macmillan.
Lowndes, V. (2010b) ‘The Institutional Approach’, in Marsh, D. and Stoker, G. (eds) *Theory and Methods in Political Science*. Thurd Edit. Hampshire: Palgrave Macmillan.
Lowndes, V. and Gardner, A. (2016) ‘Local governance under the Conservatives: super-austerity, devolution and the “smarter state”’, *Local Government Studies*. Routledge, 42(3), pp. 357–375.
Lowndes, V. and Mccaughie, K. (2013) ‘Weathering the perfect storm austerity and institutional resilience in local government’, *Policy and politics*, 41(4), pp. 533–549. doi: 10.1332/030557312X655747.
Lowndes, V. and Pratchett, L. (2012) ‘Local Governance under the Coalition Government: Austerity, Localism and the “Big Society”’, *Local Government Studies*, 38(1), pp. 21–40. doi: 10.1080/03003930.2011.642949.
Lund, H. *et al.* (2010) ‘The role of district heating in future renewable energy systems’, *Energy*, 35(3), pp. 1381–1390. doi: 10.1016/j.energy.2009.11.023.
Lund, H. *et al.* (2014) ‘4th Generation District Heating (4GDH). Integrating smart thermal grids into future sustainable energy systems.’, *Energy*. Elsevier Ltd, 68, pp. 1–11. doi: 10.1016/j.energy.2014.02.089.
Lutsch, W. R. (2014) *Heat and the German Energiewende*. Brussels, Belgium, EuroHeat and Power.
Lutsch, W. R. and Orita, S. (2009) ‘District heating in Germany: a market renaissance’, *Cogeneration and Onsite Power Production*.
Maassen, A. (2012) ‘Heterogeneity of Lock-In and the Role of Strategic Technological Interventions in Urban Infrastructural Transformations’, *European Planning Studies*, 20(3), pp. 441–460. doi: 10.1080/09654313.2012.651807.
MacKay, D. (2009) *Sustainable Energy — without the hot air*. Cambridge: UIT.
Magnusson, D. (2013) *District Heating in a Liberalized Energy Market: A New Order? - Planning and Development in the Stockholm Region, 1978-2012*. Available at: http://www.diva-portal.org/smash/record.jsf?pid=diva2:605579.

Mahoney, J. and Thelen, K. (2010) *Explaining institutional change: agency, ambiguity and power, Cambridge: CUP*. Cambridge: Cambridge University Press.
March, J. and Olsen, J. (2008) 'The Logic of Appropriatness', in Goodin, R. E., Moran, M., and Rein, M. (eds) *The Oxford Handbook of Public Policy (online)*. Available at: http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199548453.001.0001/oxfordhb-9780199548453-e-034?print=pdf.
Marsh, D. (2010) 'Meta-Theoretical Issues', in Marsh, D. and Stoker, G. (eds) *Theory and Methods in Political Science*. 3rd edn. Palgrave Macmillan, pp. 212–231.
Marsh, D. and Furlong, E. (2002) 'A skin not a sweater: Ontology and Epistemology in Political Science', in Marsh, D. and Stoker, G. (eds) *Theory and Methods in Political Science*. 2nd edn. Basingstoke, UK: Palgrave Macmillan, pp. 184–211.
McCann, E. (2017) 'Governing urbanism: Urban governance studies 1.0, 2.0 and beyond', *Urban Studies*, 54(2), pp. 312–326.
Meadowcroft, J. (2009) 'What about the politics? Sustainable development, transition management, and long term energy transitions', *Policy Sciences*, 42(4), pp. 323–340. doi: 10.1007/s11077-009-9097-z.
Mitchell, C. (2014) *Change and Inertia in the UK Energy System – getting our institutions and governance right.* EPG Working Paper 1402. University of Exeter, Energy Energy Policy Group.
Monstadt, J. (2007) 'Urban Governance and the Transition of Energy Systems: Institutional Change and Shifting Energy and Climate Policies in Berlin', *International Journal of Urban and Regional Research*, 31(2), pp. 326–343. doi: 10.1111/j.1468-2427.2007.00725.x.
Morris, C. and Pehnt, M. (2012) *Energy Transition: The German Energiewende*. Heinrich Böll Foundation.
Moss, T., Becker, S. and Naumann, M. (2014) 'Whose energy transition is it, anyway? Organisation and ownership of the Energiewende in villages, cities and regions', *Local Environment*, (November 2014), pp. 1–17.
Mountfield, H. (2012) *The 'general power of competence' in the localism act 2011: devolving democracy or the end of accountability?* London, Public Law

Project.
National Audit Office (2014) *The impact of funding reductions on local authorities*. London, NAO.
Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
NERA and AEA (2010) *Decarbonising Heat : Low-Carbon Heat Scenarios for the 2020s Report for the Committee on Climate Change*. London, CCC.
Nolan, A. (2013) *Sheffield & District Energy Network Development*. Sheffield City Council.
Nolden, C. (2013) 'Governing community energy — Feed-in tariffs and the development of community wind energy schemes in the United Kingdom and Germany', *Energy Policy*. Elsevier, 63, pp. 543–552.
O'Gorman, K. and MacIntosh, R. (2015) 'Mapping Research Methods', in MacIntosh, R. and O'Gorman, K. (eds) *Research Methods for Business & Management. A guide to writing your dissertation*. Second. Oxford: Goodfellow, pp. 50–74.
OECD (2015) *The Metropolitan Century: Understanding urbanisation and its consequences. Policy Highlights*.
Oñate, V. G. (2013) *STEP-UP: Trajectory 4 Market model heating networks: Benchmark of DH markets in Sweden, Denmark, and Belgium*. STEP UP Project, European Commission.
Oosterlynck, S. and González, S. (2013) '"Don't Waste a Crisis": Opening up the City Yet Again for Neoliberal Experimentation', *International Journal of Urban and Regional Research*, 37(3), pp. 1075–1082.
Orita, S. (2013) *Country by country assessment: Germany*. EuroHeat and Power.
Ostertag, K. *et al.* (2007) 'Local utilities, liberalisation and the EU Emission Trading Scheme: Emerging strategies and their determinants', in *6th Conference on Applied Infrastrcuture Research, 5-6 October 2007, Berlin*.
Osterud, O. (1996) 'Antinomies of Postmodernism in International Studies', *Journal of Peace Research*, 33(4), pp. 385–90.
Parsons Brinkerhoff (2014) *District Heating and Combined Heat & Power*. London.
Peck, J., Theodore, N. and Brenner, N. (2010) 'Postneoliberalism and its

Malcontents', *Antipode*, 41(April 2009), pp. 94–116.
Persson, U., Möller, B. and Werner, S. (2014) 'Heat Roadmap Europe: Identifying strategic heat synergy regions', *Energy Policy*. Elsevier, 74, pp. 663–681. doi: 10.1016/j.enpol.2014.07.015.
Pettigrew, A. M. (1990) 'Longitudinal Field Research on Change: Theory and Practice', *Organization Science*, 1(3), pp. 267–292.
Platt, R., Williams, J., *et al.* (2014) *A new apporach to electricity market. How new disruptive technologies change everything*. London, IPPR.
Platt, R., Straw, J., *et al.* (2014) *City Energy: A New Powerhouse for Britain*.
Van de Poel, I. (2000) 'On the role of outsiders in technical development.', *Technology Analysis and Strategic Management*, 12, pp. 383–397.
Pohlmann, A. (2011) *Local Climate Change Governance Global Transformations Towards A Low Carbon Society*. Worknig Paper Series: 5. University of Hamburg.
Poyry Energy and Faber Maunsell (2009) *The potential and costs of district heating networks. Report to DECC.* London: Department of Energy and Climate Change.
Prognos (2015) *Hintergrundpapier zur Energieeffizienzstrategie Gebäude (Background paper for the Energy efficiency strategy)*. Berlin.
Provost, C. and Kennard, M. (2015) 'The obscure legal system that lets corporations sue countries', *The Guardian*, 10 June. Available at: https://www.theguardian.com/business/2015/jun/10/obscure-legal-system-lets-corportations-sue-states-ttip-icsid.
Randall, J. and Casebourne, J. (2016) *Making devolution deals work*. London, Institute for Government.
Rao, L. *et al.* (2017) *Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids*. Paris, France: International Energy Agency.
Raven, R. *et al.* (2013) *Call for Papers: International workshop on 'Constructing and contesting spaces for low-carbon energy innovation' November 26-28 2013*. Eindhoven University of Technology, the Netherlands Abstract.
Raven, R., Schot, J. and Berkhout, F. (2012) 'Space and scale in socio-technical transitions', *Environmental Innovation and Societal Transitions*. Elsevier B.V., 4, pp. 63–78. doi: 10.1016/j.eist.2012.08.001.

Rhodes, R. a. W. (2007) ‘Understanding Governance: Ten Years On’, *Organization Studies*, 28(8), pp. 1243–1264. doi: 10.1177/0170840607076586.
Rhodes, R. A. W. (2013) ‘Political anthropology and public policy: Prospects and limits’, *Policy and politics*, 41(4), pp. 481–96.
Riahi, L. (2016) *District Energy in Cities*. Nairobi, Kenya: UNEP.
Ricardo Energy and Environment (2015) *National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK*. London, DECC.
Richter, M. (2013) ‘Business model innovation for sustainable energy: German utilities and renewable energy’, *Energy Policy*, 62, pp. 1226–1237. doi: 10.1016/j.enpol.2013.05.038.
Rip, A. and Kemp, R. (1998) ‘Technological change’, in Rayner, S. and Malone, E. . (eds) *Human Choice and Climate Change*. Second Edi. Battelle Press, Columbus, OH, pp. 327–400.
Roelich, K. *et al.* (2013) ‘The role of governance in accelerating transition towards more integrated, service-oriented infrastructure operation.’, in *Theorising governance change for a sustainable economy*. British Library, p. 30 April 2013.
Rohracher, H. and Spath, P. (2013) ‘The Interplay of Urban Energy Policy and Socio-technical Transitions: The Eco-cities of Graz and Freiburg in Retrospect’, *Urban Studies*, pp. 1–17. doi: 10.1177/0042098013500360.
Russell, S. (1986) *The political shaping of energy technology: Combined Heat and Power in Britain*. University of Aston.
Russell, S. (1993) ‘Writing Energy History: Explaining the Neglect of CHP/DH in Britain’, *British Journal for the History of Science*, 26(1), pp. 33–54.
Russell, S. (2010) *Background Paper CHP and DH to the mid-1990s*. University of Edinburgh.
Rutherford, J. and Coutard, O. (2014) ‘Urban Energy Transitions: Places, Processes and Politics of Socio-technical Change’, *Urban Studies*, 51(7), pp. 1353–1377. doi: 10.1177/0042098013500090.
Rydin, Y. *et al.* (2013) ‘Mapping the coevolution of urban energy systems: pathways of change’, *Environment and Planning A*, 45(3), pp. 634–649.
Sandford, M. (2014) *Local authorities: the General Power of Competence*. London, House of Commons Library.

Sandford, M. (2016) *Devolution to local government in England*. London, House of Commons Library.
Schmidt, S., Jäger, T. and Karl, U. (2012) 'The Transition of the Residential Heat Market in Germany - A System Dynamics Approach', in *Conference Proceedings The 30th International Conference of the System Dynamics Society St. Gallen, Switzerland, July 22-26*.
Schmidt, V. (2006) 'Chapter 5: Institutionalism', in Hay, C., Lister, M., and Marsh, D. (eds) *The State: Theories and issues*. Baskingstoke, Hampshire: Palgrave Macmillan, pp. 98–116. doi: 10.1016/B978-0-12-374849-2.00005-8.
Schmidt, V. (2010a) 'Analyzing Ideas and Tracing Discursive Interactions in Institutional Change: from Historical Institutionalism to Discursive Institutionalism', *Paper prepared for presentation for the panel: "Ideas, Power and Public Policy" at the Annual Meetings of the American Political Science Association, Washington DC, September 2-5, 2010*, p. 28.
Schmidt, V. (2010b) 'Taking ideas and discourse seriously: explaining change through discursive institutionalism as the fourth "new institutionalism"', *European Political Science Review*, 2(01), p. 1.
Schmidt, V. . (2008) 'Discursive Institutionalism: The Explanatory Power of Ideas and Discourse', *Annual Review of Political Science*, 11(1), pp. 303–326. doi: 10.1146/annurev.polisci.11.060606.135342.
Schmidt, V. A. (2002) 'Does discourse matter in the politics of welfare state adjustment?', *Comparative Political Studies*, 35(2), pp. 168–193.
Schmidt, V. A. (2008) *Bringing ideas and discourses back into the explanation of change in varieties of capitalism and Welfare States*. 2. Brighton.
Schmidt, V. A. and Radaelli, C. M. (2004) 'Policy Change and Discourse in Europe: Conceptual and Methodological Issues', *West European Politics*, 27(2), pp. 183–210. doi: 10.1080/0140238042000214874.
Schoenberger, P. (2013) *Municipalities as Key Actors of German Renewable Energy Governance: An Analysis of Opportunities, Obstacles, and Multi-Level Influence*. 186. Wuppertal Institute for Climate, Environment and Energy.
Schönberger, P. (2013) *Municipalities as key actors of German renewable energy governance: An analysis of opportunities, obstacles, and multi-level influences*. No. 186. Wuppertal Institute for Climate, Environment and Energy.
Schönberger, P. and Reiche, D. (2016) 'Why Subnational Actors Matter: The

Role of Länder and Municipalities in the German Energy Transition', in Hager, C. and Stefes, C. H. (eds) *Germany's Energy Transition: A Comparative Perspective*. Berlin Heidelberg: Springer, pp. 27–61.
Scottish Government (2017) *Consultation on heat and energy efficiency strategies, and regulation of district heating*. Edinburgh.
Scrase, I. and Smith, A. (2009) 'The (non-)politics of managing low carbon socio-technical transitions', *Environmental Politics*, 18(5), pp. 707–726.
Sharp, L. I. Z. and Richardson, T. I. M. (2001) 'Reflections on Foucauldian Discourse Analysis in Planning and Environmental Policy Research', *Journal of Environmental Policy & Planning*, 3(May), pp. 193–209.
Sheffield City Council (2011) *Sheffield Development Framework: Climate Change and Design Supplementary Planning Document*. Sheffield.
Sheffield City Council (2016) *Green City Strategy*. Sheffield City Council.
Shove, E. and Walker, G. (2007) 'CAUTION ! Transitions ahead : politics , practice and sustainable transition management', *Environment and Planning A*, 39, pp. 763–770.
Smith, A. and Stirling, A. (2008) *Social-ecological resilience and socio-technical transitions: critical issues for sustainability governance*. The STEPS Centre, University of Sussex.
Smith, A., Stirling, A. and Berkhout, F. (2005) 'The governance of sustainable socio- technical transitions.', *Research Policy*, 34(10), pp. 1491–1510.
Smith, A., Voß, J.-P. and Grin, J. (2010) 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges', *Research Policy*, 39(4), pp. 435–448. doi: 10.1016/j.respol.2010.01.023.
Smith, M. (2012) *CDEA Annual Conference - 'Energizing Communities'*.
Späth, P. and Rohracher, H. (2010) '"Energy regions": The transformative power of regional discourses on socio-technical futures', *Research Policy*, 39(4), pp. 449–458. doi: 10.1016/j.respol.2010.01.017.
Speigel Online (2007) 'Beust regrets the sale of HEW to Vattenfall', *Speigel Online*, 12 July.
Steinkrüger, J. (2014) *A vision of a different energy future District Heating in Frankfurt am Main*. Frankfurt am Main.
Stevenson, R. (2009) 'Discourse, power, and energy conflicts: understanding Welsh renewable energy planning policy', *Environment and Planning C:*

Government and Policy, 27(3), pp. 512–526. doi: 10.1068/c08100h.
Stoker, G. (1998) 'Governance as theory: five propositions', *International Social Science Journal*, 50(155), pp. 17–28. doi: 10.1111/1468-2451.00106.
Streeck, W. and Thelen, K. (2005) 'Introduction : Institutional Change in Advanced Political Economies', in Streeck, W. and Thelen, K. (eds) *Beyond continuity: institutional change in advanced political economies*. Oxford, Oxford University Press, pp. 1–39. doi: 10.1111/j.1467-8543.2009.00746.x.
Sustainability West Midlands (2014) *West Midlands Local Authority Low Carbon Economy Programme Implementation steps to large scale district heating*. Birmingham.
Tennet (no date) *The German Combined Heat and Power Act (KWKG)*. Available at: http://www.tennet.eu/de/en/customers/eegkwk-g/combined-german-heat-and-power-act-kwk-g.html.
Terhorst, P. (2014) *Remunicipalisation in Berlin after the buy-back: From de-privatisation to demands for democratisation*. Amsterdam. Available at: http://www.tni.org/article/remunicipalisation-berlin-after-buy-back?context=599#4.
Thelen, K. L. (1999) 'Historical Institutionalism in Comparative Politics', *Annual Review of Political Science*, 2(1), pp. 369–404.
Tims, A. (2017) *Energy customers locked into a costly scheme who have no right to switch*, *The Guardian*. Available at: https://www.theguardian.com/money/2017/feb/05/district-heating-fuel-bill-regulation (Accessed: 5 February 2017).
Tingey, M., Webb, J. and Hawkey, D. (2017) *Local Authority Engagement in Uk Energy Systems: Highlights From Early Findings*. UKERC, London and The ETI, Loughborough.
Toke, D. and Fragaki, A. (2008) 'Do liberalised electricity markets help or hinder CHP and district heating? The case of the UK', *Energy Policy*, 36(4), pp. 1448–1456. doi: 10.1016/j.enpol.2007.12.021.
Tomaney, J. (2016) 'Limits of devolution: Localism, economics and post-democracy', *Political Quarterly*, 87(4). doi: 10.1111/1467-923X.12280.
Travers, T. (2013) *Local government's role in promoting economic growth: removing unnecessary barriers to success*. Local Government Association, London.

Turner, E. and Green, S. (1998) ‘Understanding Policy Convergence in Britain and Germany’, in Green, S. and Turner, E. (eds) *Policy Convergence in the UK and Germany*. Routledge, Abingdon, Oxon.
UK Debt Management Office (2017) *Public Works Loan Board Annual Report and Accounts 2016-2017*. London.
UK government (2018) ‘Heat Networks: Ensuring Sustained Investment and Protecting Consumers’, (December). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762458/heat-networks-ensuring-sustained-investment-protecting-consumers.pdf.
UKDEA (2014) *Energy Sources*. Available at: http://www.ukdea.org.uk/en/energy-sources (Accessed: 14 September 2016).
UKERC (2013) *Written evidence submitted by the UK Energy Research Centre (HOT28). Energy and Climate Change Select Committee on Heat.* Available at: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/heat/written/1607.pdf.
UNEP (2015) *District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy*. Paris, France.
University of Bristol (2017) *Temple Quarter Enterprise Campus*. Bristol.
Unruh, G. C. (2000) ‘Understanding carbon lock-in.’, *Energy Policy*, 28, pp. 817–883.
Vattenfall (2016) *Vattenfall Secures District Heating Supply in Hamburg*, *Vattenfall*.
van der Veen, R. A. C. and Hakvoort, R. A. (2016) ‘The electricity balancing market: Exploring the design challenge’, *Utilities Policy*. Elsevier Ltd, 43, pp. 186–194. doi: 10.1016/j.jup.2016.10.008.
Verbong, G. and Geels, F. (2007) ‘The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004)’, *Energy Policy*, 35(2), pp. 1025–1037. doi: 10.1016/j.enpol.2006.02.010.
Verco (2014) *Warm homes, not warm words. Report for WWF-UK on how the UK can move to a low carbon heat system*. WWF, London.
VKU (2016) *About us*. Available at: https://www.vku.de/en/ (Accessed: 2 September 2017).
Voß, J.-P. and Bornemann, B. (2011) ‘The Politics of Reflexive Governance :

Challenges for Designing Adaptive Management and Transition Management', *Ecology and Society*, 16(2) [online]
Walberg, K. (2010) *Renewable Energies in Hamburg*. Hamburg: Ministry of Urban Development and Environment, City of Hamburg.
Webb, J. (2012) 'Enabling Urban Energy: Governance of Innovation in Two UK Cities', in *International roundtable workshop - From networked to post-networked urbanism: new infrastructure configurations and urban transitions Autun , France , 17-20 July 2012*, pp. 17–20.
Webb, J. (2015) 'Improvising innovation in UK urban district heating: The convergence of social and environmental agendas in Aberdeen', *Energy Policy*. Elsevier, 78, pp. 265–272. doi: 10.1016/j.enpol.2014.12.003.
Webb, J. and Hawkey, D. (2012) *Governing Socio-Technical Innovation: District Heating in the UK*.
Werner, S. (2017) 'District heating and cooling in Sweden', *Energy*. Elsevier Ltd, 126, pp. 419–429. doi: 10.1016/j.energy.2017.03.052.
Which? (2015) *Turning Up the Heat: Getting a fair deal for District Heating users*. London, Which?
Widmaier, W., Blyth, M. and Seabrooke, L. (2007) 'Exogenous shocks or endogenous constructions? The meanings of wars and crises', *International Studies Quarterly*, 51(4), pp. 747–759.
Wilson, D. and Game, C. (2002) *Local Government in the United Kingdom*. 3rd Editio. London: Macmillan.
Wilson, T., Crews, A. and Mirza, K. (2017) *Work Local. Report to the Local Government Association on developing a modern, local, public employment and skills service*. London, LGA.
Witte, S. (2012) *Structure and management of the distribution system operators in Germany. Efficient, innovative and reliable: Local public enterprises in Germany*. Lyon, VKU.
Wollmann, H. (2004) 'Local Government Reforms in Great Britain, Sweden, Germany and France: Between Multi-Function and Single-Purpose Organisations', *Local Government Studies*, 30(4), pp. 639–665.
Wollmann, H. (2012) 'Public Service Provision in European Countries: from municipal to private sector - and back to municipal?', in *22nd World Congress of IPSA*, pp. 1–25.

Woodman, B. (2002) *Shifting the balance of power? Renewables and distributed generation in liberalised electricity systems*. University of Sussex.
Workman, M. (2015) *Economic Resilience of UK Cities? The role of cities in the UK energy agenda - Their importance as facilitators and co-ordinators*. London, Energy Research Partnership.
Yildiz, Ö. *et al.* (2014) *Research Perspectives on Renewable Energy Cooperatives in Germany: Empirical Insights and Theoretical Lenses*.
Yin, R. (2010) 'Analytic Generalization', in Mills, A. J., Durepos, G., and Wiebe, E. (eds) *Encyclopedia of Case Study Research*. Thousand Oaks, CA: Sage, pp. 21–23.
Yin, R. (2014) *Case Study Research: design and methods*. 5th Editio. Thousand Oaks, California: Sage.